Journal of Agricultural Education, 55(2), 106-119.
doi: 10.5032/jae.2014.02106

Determining the Effects that the Order of Abstraction and Type of Reflection have on Content Knowledge When Teaching Experientially: An Exploratory Experiment

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Abstract

The purpose of this experimental study was to determine the effects of order of abstraction and type of reflection on student knowledge acquisition. Students were assigned randomly to one of four treatment combinations in the completely randomized 2x2 design which included either abstraction prior to or directly after an experience, and either reflection-in-action or reflection-on-action. A Lab-Aids® inquiry-based kit, centered on the principles of biofuels, served as the content for the treatment. The findings of this study indicate that order of abstraction does not have a statistically significant effect on knowledge acquisition scores, but that reflection-in-action did have a statistically significant effect on increasing students' knowledge of the selected biofuel concepts. It is recommended that teachers at both the secondary and university level focus on effective strategies of reflection-in-action to draw deeper, more enduring learning from students' experiences in agricultural education. The study was exploratory in nature, and recommendations were suggested for full-scale replications of the study.

Keywords: experiential learning; experiment; abstraction; reflection; biofuels

This project was supported, in part, by the National Science Foundation EPSCoR award EPS 0814361.

Introduction

Experiential learning has been an integral part of agricultural education since its inception (Baker, Robinson, & Kolb, 2012; Cheek, Arrington, Carter, & Randall, 1994; Hughes & Barrick, 1993; Knobloch, 2003; McLean & Camp, 2000; Roberts, 2006). "Agricultural education has a great advantage in that the entire program is so easily experiential" (Baker et al., 2012, p. 6). The National Research Council (1988) spoke to the power that hands-on, experiential learning possessed for improving agricultural education students' understanding of science.

Though the opportunities for experiential learning in agricultural education are numerous, the meaningfulness of such experiences should be considered (Tyler, 1949). Experiences in agricultural education alone do not constitute learning (Baker et al., 2012). Dewey (1938) explained, "unless experience is so conceived that the result is a plan for deciding upon subject-

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matter, upon methods of instruction and discipline, and upon material equipment and social organization of the school, it is wholly in the air" (p. 28). Knobloch (2003) stated that the biggest challenge agricultural educators face is being able to move beyond the *doing* to ensure that the experiences are leading to enhanced thinking and content knowledge.

Evidence suggests that experiences in agricultural education are meaningful to students (Abdulwahed & Nagy, 2009; Cheek et al., 1994; Dyer & Osborne, 1995; Eyler & Halteman, 1981; Eyler & Giles, 1999; Specht & Sandlin, 1991; Steinke & Buresh, 2002). When students are engaged in experiences grounded in authentic pedagogy, intellectual achievements are likely to follow (Knobloch, 2003). The key is the presence of purposeful pedagogical support. However, despite the potential benefits of experiential learning on student achievement, little is reported in terms of how to teach experientially. Though agricultural educators may utilize elements of experiential learning, they lack formal knowledge about the learning process and how to transition students throughout the complete cycle (Arnold, Warner, & Osborne, 2006). This challenge stems in part from the lack of effective structures to help instructors guide students from a concrete experience to the deduction of abstract concepts (Ash & Clayton, 2004).

Theoretical and Conceptual Framework

Kolb's (1984) experiential learning theory (ELT) explains how knowledge is created through the transformation of experience; thus, it provided the foundation for this study. Kolb (1984) described ELT as a four-step learning process, including concrete experience, reflective observation, abstract conceptualization, and active experimentation (see Figure 1). These four modes of learning create a two dimension learning procedure—grasping information and transforming information. Learning can begin at any stage, but it is essential that learners complete the full cycle (Kolb, 1984).

Roberts (2006) noted there are diverse ideas of what constitutes experiential learning. According to Kolb (1984), all learning is experiential and can occur in a variety of different contexts. Traditionally, Supervised Agricultural Experiences (SAE) have been described as the experiential component of agricultural education (Newcomb, McCracken, Warmbrod, & Whittington, 2004), but Baker et al. (2012) challenged this idea by proposing an Experiential Agricultural Education Model elucidating the important role of experiential learning in all components of agricultural education. Roberts (2006) proposed a Model of the Experiential Learning Process that identifies more explicitly the context by which an experience occurs. Roberts (2006) recommended that researchers and practitioners should utilize the model to define learning experiences more clearly. This model is composed of four dimensions: the level, duration, intended outcome, and setting.

One of the biggest disconnects in the use of experiential learning is the missing connection between the teacher and the experience (Baker et al., 2012). An educator plays an important role at each stage of the learning process. As students transition from a concrete experience into reflection, the teacher serves as a facilitator by drawing out their interests, ideas, and previous knowledge. The educator becomes an expert as students transition into abstraction by providing guidance in the organization and connection of their reflections to the subject matter of interest. Next, the educator assumes the role of an evaluator by setting standards and helping students master the required concepts or skills during active experimentation. This learning stage is where a practice makes perfect approach is appropriate. Finally, as a coach, an educator helps learners apply knowledge to achieve their goals (Baker et al., 2012). The facilitator and expert roles provide the opportunity for educators to guide students toward learning goals and objectives, which are of specific interest in this study.

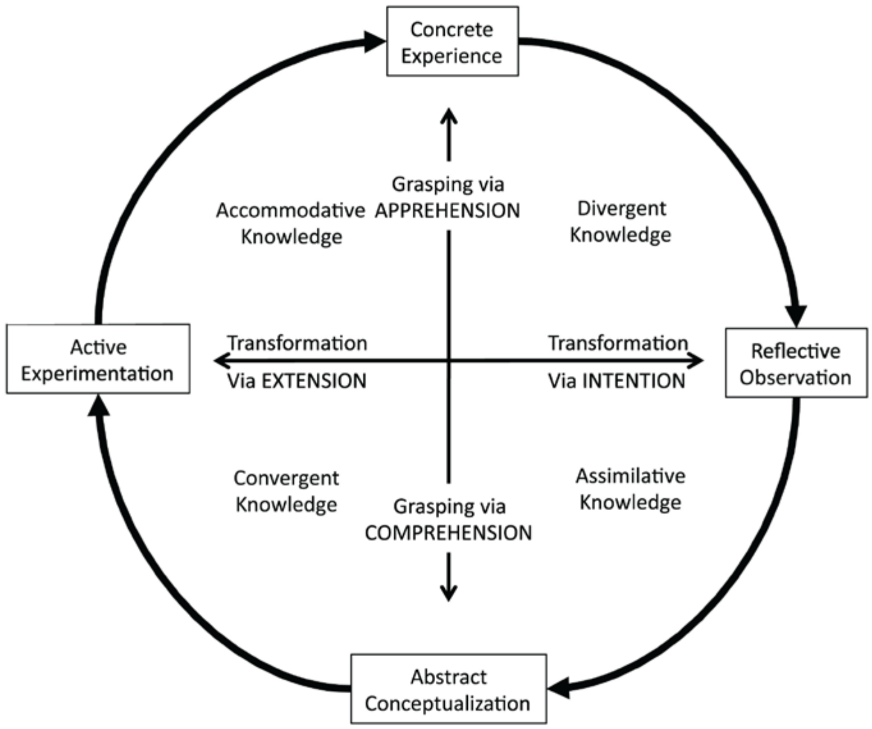

Figure 1. Model of Experiential Learning Process. Reprinted from *Experiential Learning: Experience as the Source of Learning and Development* (p. 42), by David A. Kolb, 1984, Englewood Cliffs, NJ: Prentice-Hall, Inc. Copyright 1984 by Prentice-Hall, Inc. Reprinted with permission.

Reflection – The Facilitator Role

Kolb's (1984) ELT is dependent on reflection for learning to occur (Moon, 1999; Sobral, 2000). Reflection is designed to assist individuals in improving their practice (Schön, 1983). Therefore, aspiring teachers should be interested in improving their practice as it relates to content knowledge and pedagogy (McAlpine & Weston, 2000).

York-Barr, Sommers, Ghere, and Montie (2001) stated, "reflective practices facilitate learning, renewal, and growth throughout the development of career educators" (p. 1). Schön (1983) developed two types of reflection: reflection-in-action and reflection-on-action. Reflection-in-action is continuous during the teaching process. This is when individuals think about the decisions they make while experiencing learning. It is synchronous, or in harmony with, the activities being conducted in class in *real time*. In contrast, reflection-on-action is that which is conducted after a learning experience has been completed (Schön, 1983). It is referred to as asynchronous reflection because it occurs after the activities have been conducted. McAlpine and Weston (2000) stated that, "reflection-on action provides the opportunity for dramatic, extensive structural changes, and is more likely to take place in the strategic or epistemic sphere" (p. 365).

"Reflection is a mechanism for the construction of knowledge from experience" (McAlpine & Weston, 2000, p. 371), and thus plays an integral role in enabling effective learning to occur (Moon, 1999). "Although there is a general belief that reflection is a useful tool for developing and improving teaching, it is apparent that not all teachers appear to reflect" (McAlpine & Weston, 2000, p. 379). One reason teachers fail to reflect is because they have little knowledge of the pedagogy and art of reflection (McAlpine & Weston, 2000). For the students involved in this study, this implication could be true, especially since these individuals were novice teachers. The subjects of this study were junior-standing students in their first college course related to their teaching major.

Reflecting critically on experiences can be aided through working in collaborative settings in student-centered environments (Jonassen, Davidson, Collins, Campbell, & Haag, 1995). In fact, reflection can be enhanced when learners are able to form a community of practice (Lave & Wenger, 1991) in student-centered settings and experience real-world problems in which they negotiate their decisions both internally and within their social groups (Jonassen et al., 1995).

Moon (1999) concluded that the role reflection plays in experiential learning is unclear and needs to be studied further because, depending on which type of reflection is used (reflection-in-action or reflection-on-action), the outcome of the experience can be affected. Ash and Clayton (2004) recommended that for reflection to be impactful, it must be rigorous and meaningful to students. Providing reflection that is rigorous depends on allowing students to describe their experiences objectively, analyze the problems embedded in the situation accurately, and articulate the outcomes of those experiences clearly. When completed, reflecting while learning can produce higher grade point averages, self-perceptions toward completing a task, meaningfulness of the activity being experienced, and test scores (Sobral, 2000).

Although experiential learning can improve individuals' abilities to think at deeper levels of cognition (Moon, 1999), what role should teachers play in the reflection process? Is reflection-in- or reflection-on-action best for optimizing students' abilities to think at higher levels and solve real-world problems? Asked another way, do teachers impede or promote students' abilities to reflect and draw meaning by the type of reflection they prescribe?

Abstract Conceptualization – The Expert Role

Abstract conceptualization is defined by Kolb (1984) as the process by which knowledge is grasped through reliance on conceptual interpretation and symbolic representation. This mode of learning, also called comprehension, involves the process of bringing order to the various sensations that are apprehended during an experience. Learners' memories of the numerous interactions with their environment fade quickly if not processed and attached to previous schemas on a given topic (Kolb, 1984).

Though a review of literature exposed a paucity of research regarding abstract conceptualization, the idea of making meaning from experience is discussed indirectly by a number of researchers (Dewey, 1973, 1916; Hutchings & Wutzdorff, 1988; Wurdinger, 2005). Most often, the discussion in those works revolved around the timing in which abstraction should occur in relation to the experience. Dewey (1973) distinguished between primary and secondary experiences and postulated that the primary experience must occur before any secondary experience such as reflection or abstraction. Dewey (1916) explained that "an ounce of experience is better than a ton of theory simply because it is only in experience that any theory has vital and verifiable significance" (p. 144). Educators have witnessed Dewey's claim and explained that when theory is presented before concrete experiences, students simply recite the theory with little to no meaning or application (Hutchings & Wutzdorff, 1988; Wurdinger, 2005).

In contrast, some educators believe that the presentation of abstract concepts prior to an experience provides valuable context that is necessary for students to optimize learning and interact with various stimuli. Abdulwahed and Nagy (2009) attributed poor learning outcomes of various laboratory experiences to weak activation of the prehension dimension before entering the lab experience. It was reported that the laboratory experience became an "algorithmic following of the lab manual instead of actively constructing meaningful knowledge out of it" (p. 285). Pre-lab sessions, which included the presentation of abstract concepts related to the lab, were found to have a statistically significant effect on learning outcomes. This sentiment was also discussed in agricultural education, as teachers discussed their preference to begin instruction by setting a theoretical context so that students could grasp the concepts during the experience better (Arnold, Warner, & Osborne, 2006).

A third perspective, proposed by Kolb (1984), is that the timing of the experience is not of concern. More important, is a conscious effort by the instructor to begin instruction in various modes to provide each student an opportunity to work within his or her preferred mode. Each student has a preferred learning style, and teachers tend to teach in a way that is congruent to their personal style (Baker et al., 2012). Variability encourages students to increase the complexity of their thought in all four modes (Kolb, 1984).

Experiential learning is an integral part of agricultural education, and it spans across both secondary and post-secondary programs (Roberts, 2006). Therefore, how can agricultural educators, at all levels, make the most of experiences offered to students? Is it best for experiences to occur before theory? Is the theory necessary to engage students in the experience? Or, is the key variability? The answers to these questions have implications for both teachers and teacher educators.

Purpose and Objectives

The purpose of this study was to determine the effect of reflection-in-action and reflection-on-action regarding content knowledge, the effect that the order of abstraction had on content knowledge, and whether or not an interaction existed between type of reflection and order of abstraction on content knowledge scores. The following objectives guided this study.

1. Describe the effect an interaction between order of abstraction and type of reflection has on content knowledge scores.
2. Describe the variance in content knowledge scores attributed to the order of abstraction.
3. Describe the variance in content knowledge scores attributed to the type of reflection employed.

For the purpose of statistical analysis, the following null hypotheses were created.

H_0 1: There is no variance in knowledge scores due to the interaction of order of abstraction and method of reflection.

H_0 2: There is no difference in the overall mean knowledge scores between the reflection-in-action and the reflection-on-action groups.

H_0 3: There is no difference in the overall mean knowledge scores between the pre-abstraction and post-abstraction groups.

Methods and Procedures

This experimental study was exploratory in nature. Exploratory studies are "preliminary stages of a research program when the researcher does not have sufficient information to make precise predictions or formulate testable models" (Kirk, 1995, p. 118). Although researchers should seek to use samples to generalize and infer the data to larger populations, exploratory studies should always precede larger ones (Kirk, 1995). Because this study was the first of its kind, it was defined as exploratory. "Exploratory studies have three purposes: to discover significant variables in the field situation, to discover relations among variables, and to lie a groundwork for later, more systematic and rigorous testing of hypotheses" (Kerlinger, 1964, p. 388). This research study employed a completely randomized factorial (CRF) 2x2 design (Kirk, 1995). CRF designs are appropriate when two independent variables and their combined effects are of interest (Ary, Jacobs, & Razavieh, 2002). Specifically, the independent variables in this research study were order of abstraction and type of reflection. The dependent variable of interest in this study was biofuels content knowledge, as measured on a 20-item criterion-referenced test.

The population of interest was students enrolled in a junior level, post-secondary foundations course for pre-service teachers in agricultural education (*N* = 45) at Oklahoma State University. This experimental study was couched within teaching and learning in the agriscience laboratory and was included in the course syllabus. Early in the semester, the students were informed of this topic in the syllabus and the importance of agriscience laboratory experiences. These students were assigned randomly to one of four treatment groups. These groups were constructed based on order of abstraction and type of reflection. Regarding order of abstraction, students were assigned randomly to a pre-abstraction or post-abstraction group. The students in the pre-abstraction groups participated in a biofuels lecture/discussion that provided abstract concepts of biofuels, and then participated in an agriscience laboratory experience focusing on biofuels. The students in the post-abstraction groups engaged in the biofuels agriscience laboratory experience first, followed by the biofuels lecture/discussion abstraction. Regarding type of reflection, one-half of the students received pedagogy employing reflection-in-action and the other one-half of the students received pedagogy employing reflection-on-action.

The design of this study allowed for control of threats to internal validity. Random assignment to treatment groups is a powerful control of threats to internal validity (Gay, Mills, & Airasian, 2009). Campbell and Stanley (1963) described random assignment to treatment groups as “the all-purpose procedure for achieving pretreatment equality of groups” (p. 6). Specifically, there are eight factors that can affect internal validity (Campbell & Stanley, 1963). Regarding this study, seven of the eight threats were either controlled by random assignment to treatment groups or were a non-issue. Experimental mortality, however, was a threat, which impacted this research study. All students (*N* = 45) enrolled in the course were assigned randomly to one of four treatment groups. However, only 33 students participated fully in all assigned levels of the treatment. The remaining 12 students who did not complete the assigned treatments were removed from the study. This threat to internal validity was addressed by collecting demographic data from all potential students and comparing those data of the total class population to the study’s participants (Gay et al., 2009). No statistically significant differences were found in the demographic makeup of the participants when compared to the total class population; therefore, experimental mortality was determined not to be a threat to internal validity.

Moor and Piergiovani (2003) utilized laboratory kits in engineering to facilitate Kolb’s (1984) ELT learning process in a more formal setting where the laboratory and classroom were separated by space and time. This rationale drove the decision to utilize the Lab-Aids® biofuels laboratory kit in the more formal setting of the agricultural education classroom at Oklahoma State University. In response to Roberts’ (2006) call for a clearer definition of experiences, the kit-based biofuels laboratory experience was conducted in a more formal setting, where identifications were the intended outcome, the content was split equally between concrete and abstract, and the duration of the intervention was two weeks. The experience included a laboratory investigation, an opportunity to reflect through personal journaling and group discussions, introduction of abstract conceptualization through a classroom lecture, and finally a chance for re-experimentation through repeated trials and on-going discussions regarding the findings of students’ experiments.

The experimental intervention, or treatment, occurred during the course of two weeks and consisted of a lecture/discussion abstraction experience and two experiential laboratory investigations, defined by type of reflection. On day one of the first week, the two pre-abstraction groups attended a 50-minute lecture over biofuels content. Subsequently, the two post-abstraction groups met to perform experiential agriscience laboratory investigations related to biofuels. The two post-abstraction groups were divided by type of reflection and performed their agriscience laboratory investigations simultaneously in different laboratories to maintain fidelity of the reflection treatment (see Figure 2). This process was reversed on the second treatment day providing the full treatment combination for all groups. Common laboratory reflection guides, identical instructors, and a PowerPoint® presentation were utilized to maintain consistency of treatments.

	Reflection- In-Action	Reflection- On-Action
Pre-Abstraction	Treatment Group A *n = 8*	Treatment Group B *n = 7*
Post-Abstraction	Treatment Group C *n = 7*	Treatment Group D *n = 11*

Figure 2. Random assignment of participants into a CRF 2x2 design.

The abstraction experience was a classroom presentation and discussion over biofuels content. The objective of this lesson was to teach the basic biofuels terminology and concepts, discuss the laboratory experience, and foster discussion around students' interest in and experience with biofuels. A researcher who was not involved in the laboratory experience taught the classroom lecture. This experience sought to provide the theory, or abstract concepts, related to the overall teaching objectives of the investigative experience provided by Lab-Aids®.

The biofuels agriscience laboratory experience was based on the Lab-Aids® Incorporated Biofuels: Investigating Ethanol Production and Combustion kit. Specifically, the laboratory experience focused on the second investigation, Comparing the Energy Stored in Two Fuels (Lab-Aids Kit 39S, 2007). During this investigation, students determined the energy levels of two fuels, kerosene and ethanol, and then used mathematical calculations to make decisions based on hypotheses they developed. Major concepts tied to these objectives included the chemical composition of various fuels, the chemical process of combustion, pollutants, specific heat, experimental control, agricultural commodities, averaging, and conversions. To ensure fidelity between the biofuels laboratory experiences, the participants were given laboratory reports based on the Lab-Aids® investigation. The technical information contained in the laboratory reports was consistent across both groups.

In addition to timing of abstraction, students were assigned randomly to one of two reflection groups, reflection-in-action or reflection-on-action. During the biofuels agriscience laboratory experience, those students assigned to reflection-in-action reflected throughout the investigation as the laboratory instructor asked probing questions of the group. Additionally, the laboratory report provided to the reflection-in-action group was designed to ensure each student reflected during the investigation. This reflection-in-action was purposeful, requiring the students to pause during their investigations and reflect on the current situation. The students assigned to the reflection-on-action pedagogy were allowed to complete the biofuels agriscience laboratory experience without interruption. The laboratory instructor then utilized probing questions to encourage the students to reflect on their experiences at the end of the experiment. Additionally, the laboratory report provided to this group was designed to promote reflection after the completion of the investigation.

Data were collected using a researcher-developed, criterion-referenced test. Test items were created based on questions and content found in the Lab-Aids® curriculum pamphlets. These pamphlets contained the curricular information that students used to complete the laboratory assignments. To ensure credibility on criterion-referenced tests, Wiersma and Jurs (1990) recommended eight factors that researchers should address prior to implementing tests with students. Wiersma and Jurs (1990) recommended that criterion-referenced tests should consist of homogeneous items, contain discriminating items, and that there should be enough items included for students to answer. Further, the authors suggested that the test should be of high quality, have clear directions for students who are participating in the testing procedure, be conducted in a controlled setting, contain efforts to motivate students to participate at a high level, and include clear directions for the scorer who is assigned to assess the test.

The criteria suggested by Wiersma and Jurs (1990) were met by ensuring the test questions were homogenous regarding content and context. This was accomplished by ensuring that each item included was of the same font size and style and that all questions emanated from the Lab-Aids® booklet students used to participate in the experiments. Further, researchers attempted to include discriminating questions with a wide variety of difficulty. Specifically, an equal number of multiple-choice items at the lower-order cognitive level and open-ended, essay questions at the higher-order cognitive levels were included. An expert in test design assessed the questions to ensure an equal representation existed. The test was lengthened to include 20 multiple-choice questions as a means for allowing students to capitalize on their knowledge of biofuels as a result of participating in the experiments. Again, the panel of experts used to assess the tests' face and content validity helped inform the researchers at to what an acceptable test length should be, based on the intervention employed.

To ensure quality copying and format, tests were copied on a laser jet printer with equal distribution between questions for ease of reading and interpretation. Test booklets were saddle-stitched for ease of student handling to ensure test booklets were clean and legible. Directions were listed at the top of the page in written form and read aloud to students prior to testing. The instructions were provided to minimize student error and confusion during the assessment.

The test was administered in a controlled laboratory where students were accustomed to meeting for microteachings each week, enabling students to feel safe and comfortable while testing. Throughout the intervention, and again prior to testing, students were given motivating instructions and reminded of the importance of doing their best on the test. The students were reminded that the results of this study would inform them of how to provide experiences and reflections on those experiences as future teachers, thus, increasing their motivation to perform to the best of their abilities and answer each question honestly. Finally, the test contained a "test key" that was derived from sample questions found in the Lab Aids® booklet, which provided clear directions to the scorer. This key enabled the researchers to score the tests accurately. Based on these criteria by Wiersma and Jurs (1990), the test was deemed reliable.

A two-way independent analysis of variance (ANOVA) was used to calculate the main effects of the two independent variables as well as the interaction effect between the independent variables (Field, 2009). This particular use of ANOVA allows researchers to test the effects of the two independent variables on the dependent variable (Field, 2009). The basic logic of ANOVA is partitioning variance into that which is between and within groups (Ary et al., 2009).

To determine the significance of research findings, both statistical and practical significance effects were reported. Statistical significance was determined through setting an *a priori* alpha level at .05. This level was utilized in determining whether or not to reject the null hypotheses (Kirk, 1995). Practical significance was determined by calculating effect sizes using a Cohen's *d* statistic. Practical significance indicates whether a treatment effect is "large enough to be useful in the real world" (Kirk, 1995, p. 64). The Cohen's *d* statistic was interpreted using the following guidelines: (a) 0.2, indicating a small effect size, (b) 0.5, indicating a medium effect size, and (c) 0.8, indicating a large effect size (Kirk, 1995).

Findings

Means, with standard deviations in parentheses, for reflection-in and reflection-on action were 16.73 (1.98), and 14.67 (3.05) respectively. Pre-abstraction had a mean of 15.13 (3.27), and post abstraction had a mean of 16.00 (2.33). Complete reporting of descriptive statistics is found in Table 1. Levene's test of equality of error variance was used to ensure the assumption of equal variances was not violated, and it yielded $F(3,29) = 1.38$, $p = .27$. ANOVA was utilized and is summarized in Table 2. The interaction effect of reflection and abstraction yielded an $F(1,29) = .01$, $p = .91$, power = .051, and thus was determined to be non-significant. Accordingly, the first null hypothesis failed to be rejected. Since no simple main effects were detected, an analysis of main effects was necessary (Kirk, 1995). The main effect of type of reflection was found to be significant, $F(1,29) = 5.71$, $p = .02$, power = .637. Therefore, the null hypothesis was rejected. Since the main effect was an analysis between two means (Kirk, 1995), the practical significance of this difference was calculated using Cohen's *d*. The effect size for the difference was .80, which was described by Cohen as *large* (Kirk, 1995). There was no statistically significant main effect regarding the order of abstraction on knowledge test scores, $F(1,29) = 1.65$, $p = .21$, power = .237, resulting in a failure to reject the third and final null hypothesis.

Table 1

Mean Knowledge Test Scores for Treatment Conditions of Type of Reflection and Order of Abstraction

Type of Reflection	Order of Abstraction	*M*	*SD*	*n*
Reflection In	Pre-Abstraction	16.13	2.42	8
	Post-Abstraction	17.43	1.13	7
	Total	16.73	1.98	15
Reflection On	Pre-Abstraction	14.00	3.92	7
	Post-Abstraction	15.09	2.47	11
	Total	14.67	3.05	18
Total	Pre-Abstraction	15.13	3.27	15
	Post-Abstraction	16.00	2.33	18
	Total	15.61	2.78	33

Table 2

Analysis of Variance Summary Table

Source	*SS*	*df*	*MS*	*F*	*p*
Reflection	39.70	1	39.70	5.71*	.02[a]
Abstraction	11.43	1	11.43	1.65	.21
Reflection * Abstraction	.09	1	.09	.01	.91
Error	201.50	29	6.948		
Total	8285.00	33			

[a]Effect size = .80 per Cohen's *d* (Kirk, 1995)
*$p < .05$.

Conclusions

The lack of simple main effects indicate that order of abstraction and type of reflection are independent of each other when analyzing knowledge acquisition. This lack of interaction supports the assertion that reflection-in-action is a more effective reflection strategy regardless of when the experience occurs. The findings of this study also suggest that the order of abstraction does not affect students' ability to perform on a knowledge-based examination. This finding confirms the sentiment of Kolb (1984) who explained that the location in which an individual enters the cycle is of no concern, as students connect experiences to knowledge throughout the modes. However, the finding contradicts the viewpoints of Dewey (1916) and Hutchings and Wutzdorr (1988) regarding the importance of primary and secondary experiences. It has been purported that students are not able to embrace an experience fully without prior abstraction (Abdulwahed & Nagy, 2009; Arnold, Warner, & Osborne, 2006), but the mean test scores of participants in this study indicated differently.

In terms of reflection, participants who were asked to reflect-in-action demonstrated significant gains in knowledge scores, both statistically ($p = .02$) and practically ($d = .80$). These results indicate that the mode of reflection is important if knowledge gain is the primary goal. This finding extends the assertions of Ash and Clayton (2004) beyond the importance of quality reflection to include the type of reflection, and confirms the assertion made by Baker et al. (2012) that teachers must be present and engaged with students throughout an experience.

Recommendations for Research

As stated by Kirk (1995), exploratory studies should always be followed up with larger, more rigorous investigations that build on the findings and identified relationships. Therefore, five methodological recommendations are made regarding future research. First, the sample size ($n = 35$) is a limitation of this study and affected the overall power of the abstraction portion of the study. Due to the size of the reflection treatment effect, adequate power was achieved, but a larger sample would provide more stable findings. According to G*Power (Faul, Erdfelder, Lang, & Buchner, 2007), when considering the population of this study and the number of variables in the treatment, 76 participants were recommended to ensure a power base of .80. It is recommended that researchers achieve this sample size in full-scale replications. Second, replications should be conducted at the secondary level to explore if the effects found in this study are consistent in the secondary setting. Third, attention should be given to the duration and intensity of the abstraction treatment. Though order of abstraction was found to be insignificant in this study, it is recognized that the power (power = .237) of the analysis was weak. Fourth, measurements should extend beyond simple knowledge in future studies. Though knowledge acquisition is of importance, there are other important variables of interest such as motivation, skill acquisition, and depth of understanding. Finally, a deferred post-test would provide information on the effect of the various combinations on knowledge retention.

Recommendations for Practice

This study supports the assertion that the role a teacher plays throughout the experiential learning cycle impacts learning positively in experiential settings, such as the one employed in this study. Thus, if educators desire to strengthen academic success through experiential learning in agricultural settings, careful attention should be given to the process variables such as curriculum, teaching approaches, and teaching techniques associated with teaching through experience (Myers & Osborne, 2005). As such, it is recommended that an experiential learning method for agricultural education be identified, tested, and utilized in training teachers, designing curriculum, and evaluating teachers to avoid the situation where experiential learning is merely "in the air" (Dewey, 1938, p. 28). In addition, professional development should focus on the art of reflection, enabling agricultural educators to support student experiences that are better and more meaningful. Professors tasked with the training of pre-service teachers, along with cooperating teachers, should consider the importance of purposeful and frequent reflection-in-action techniques in training and developing future agricultural educators.

Implications and Discussion

Priority four of the current National Research Agenda (Doerfert, 2011), calls for the "design, development, and assessment of meaningful learning environments which produce positive learner outcomes" (p. 9). Experiential learning in authentic contexts is an important and prevalent learning environment in agricultural education (Knobloch, 2003), but are those experiences meaningful and supported purposefully? Agricultural educators may be ensuring that students are active, but are they ensuring they are productive? Other disciplines, such as engineering (Abdulwahed & Nagy, 2009) and liberal arts (Eyler, 2009), have identified specific methods to operationalize the experiential learning process. The solidification of an experiential learning method would aid in making it more than a term to describe and/or validate teachers being outside of the classroom.

Experiential learning can have an important role in STEM education when executed well. In creating activities and experiences for STEM integration, an individual must consider what methods should be used. Methods selected should reflect those used in teaching STEM academic areas. Parr and Edwards (2004) concluded, "Science education researchers posit that students achieve best in science when their learning experiences are constructivist (hands-on/minds-on) in design" (p. 112). Though experiential learning has been connected to experiences such as Supervised Agricultural Experiences (Dyer & Williams, 2007), it also has powerful applications in the agriscience classroom (Baker et al., 2012).

Another point of discussion is the role learning styles played in the findings of this study. Kolb (1984) asserted that all learners have a preferred learning style. This possibly could explain the lack of significance between the two orders of abstraction. If learning styles were distributed equally as a result of random assignment, the effects of the treatment may not be evident.

Doolittle and Camp (1999) called the profession to consider the learning theory of which agricultural education is based. The results of this study confirm their answer of cognitive constructivism. In today's standards-based educational climate, agricultural education should maintain the historical presence of learning through experience, while recognizing that this type of learning in a formal school setting requires purposeful planning, guided reflection, and adequate evaluation. Following any student learning experience, agricultural educators should be able to answer the question, "What was learned?"

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