Journal of Agricultural Education, 61(3), 308-320
https://doi.org/10.5032/jae.2020.03308

Examining the Effects of Reflection Type and Abstraction Order on Content Knowledge and Content Knowledge Retention During Experiential Learning

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Abstract

Experiential learning is fundamental to agricultural education. Current literature indicates some methods of pedagogically implementing experiential learning are more effective than others. The purpose of this study was to examine the effects of reflection type and abstraction order on content knowledge and content knowledge retention when teaching experientially. This research experiment was conducted with secondary school students enrolled in agriscience courses. The findings of this study indicated neither the method in which students reflected nor the order in which they received abstraction affected students' ability to attain content knowledge. However, when analyzing student content knowledge retention, a statistically significant interaction effect indicated reflection type and abstraction order were dependent upon one another. It is recommended those who are interested in knowledge retention outcomes should implement purposeful reflection-on-action techniques when delivering abstract conceptualization prior to an experience.

Keywords: experiential learning, agricultural education, reflection, abstraction, knowledge, retention

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Introduction

Experiential learning is fundamental to agricultural education curricula (Baker et al., 2012; National Association of Agricultural Educators [NAAE], 2019; Phipps et al., 2008; Roberts, 2006; Roberts & Ball, 2009; Shoulders & Myers, 2013). NAAE (2019) explained experiential learning accounts for a minimum of one-third of the integrated agricultural education model and is an essential part of instruction. Baker et al. (2012) stated that experiential learning is embedded into the entire three-circle model of agricultural education. Within agricultural classroom and laboratory settings, students should reflect on the instructor-provided content, relate their reflection to abstract educational concepts, and then experiment with their newfound knowledge in other contexts (Baker et al., 2012). Phipps et al. (2008) described experiential learning as foundational to effective teaching in agricultural education. Agricultural instruction often centers around problem-solving and skill-building, and classrooms serve as agriscience laboratories for students to perform experiments. Students are expected to learn knowledge and skills and apply them to real-life situations (Phipps et al., 2008). Roberts and Ball (2009)

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contended the two main purposes of agricultural education are to (a) prepare a skilled workforce and (b) develop lifelong learners who are agriculturally literate. To accomplish this, agricultural education welcomes experiential learning. The authors emphasized the facilitation of learning in which learners construct knowledge through experiences, "in complex social environments with teacher-to-learner and learner-to-learner interactions" (p. 87).

For experiential learning to be effective, instructors should play an active role in delivering each of the four components. Instructors are crucial to the experiential learning process because they facilitate learning through reflection, serves as content experts, and evaluate and coach students (Baker et al., 2012). While the practice of experiential learning is an integral component of agricultural education, more consideration should be given to experiential learning theory (ELT) (Roberts, 2006). While ELT is widely used in agricultural education, are agriculture instructors successfully utilizing Kolb's (1984) model of experiential learning when providing concrete, educational experiences to students? Shoulders and Myers (2013) found teachers frequently utilized less than all four components (concrete experience, reflective observation, abstract conceptualization, and active experimentation) of experiential learning. Knobloch (2003) stated this could be because a major challenge of agricultural educators is connecting concrete experiences to thinking, knowledge, and ultimately re-application. This leads to the question: Are some methods of pedagogically implementing the components of ELT more effective than others in developing students' content knowledge from a learning experience? Baker et al. (2012) suggested agricultural educators use careful planning and execution when utilizing experiential learning as a pedagogical approach.

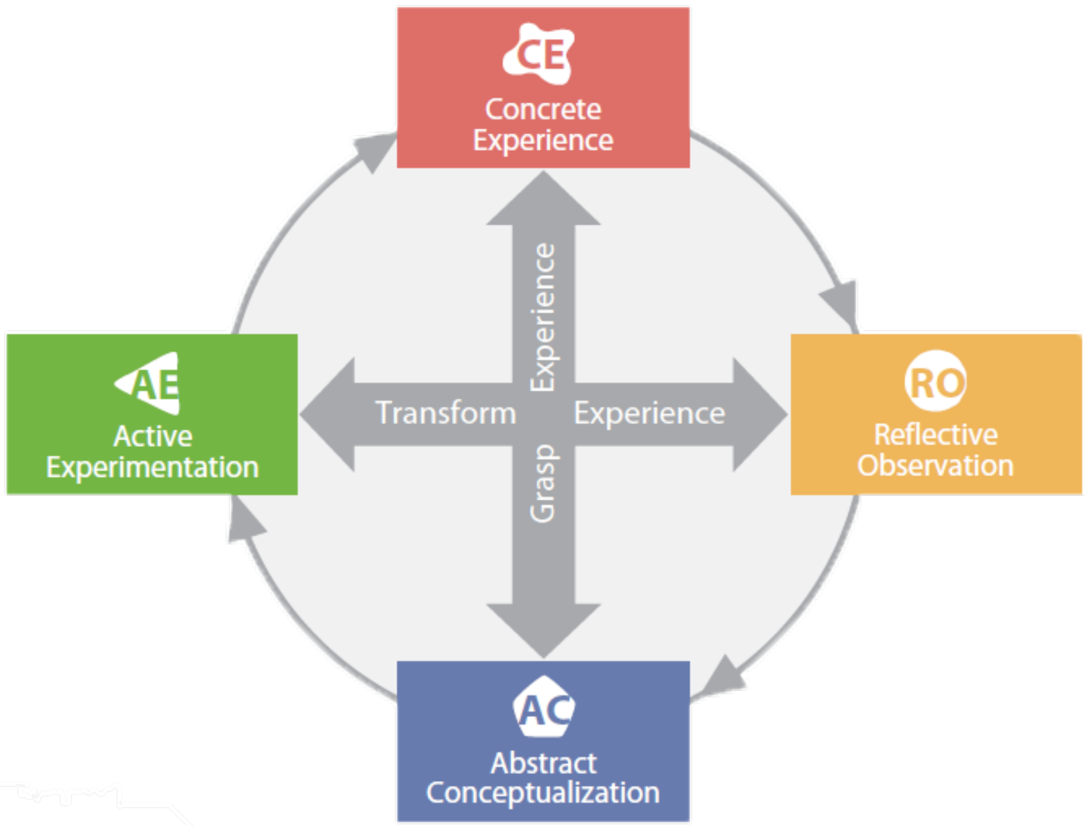
Reflection is a key component of ELT; however, are some reflection techniques more effective than others? In a study conducted by Baker et al. (2014), it was found reflection-in-action was a more effective strategy than reflection-on-action for acquiring content knowledge when used in a post-secondary school setting. The authors also found the order in which abstract conceptualization (abstraction) occurred did not affect students' content knowledge. The third finding by Baker et al. (2014) was the order of abstraction and type of reflection were independent of one another regarding the acquisition of content knowledge. In a similar study, with secondary school students, the findings indicated that the mode of reflection and order of abstraction were important factors for discussion abilities for students, but the results did not find that the type of reflection significantly impacted content knowledge gains. Further, the authors reported that the order of abstraction and type of reflection were independent of one another (DiBenedetto et al., 2017). In a study of preservice agriculture teachers at Oklahoma State University, Blackburn et al. (2015) found the type of reflection-in-action, verbal or written, did not have a significant effect on test scores, but options should be provided for students to reflect during their experiences.

Initial significant findings beget researchers to replicate studies (Dooley, 2001). Baker et al. (2014) recommended a rigorous follow-up study which would expand upon their findings. The first recommendation for research was to conduct the experiment with 76 participants which would ensure a power base of .80 (Baker et al., 2014). A second recommendation of Baker et al. (2014) was to conduct this study with secondary school students. Baker et al. (2014) measured the content knowledge gained by student, but recommended a future study should also measure other dependent variables. Specifically, administering a deferred post-test would measure students' content knowledge retention (Baker et al., 2014). DiBenedetto et al. (2017) recommended a follow-up study in a block-style class period where reflection time could be lengthened. This study sought to address these recommendations.

Theoretical Framework

The primary theory which will frame this study is experiential learning theory (ELT). Kolb (2015) defined ELT as a learning cycle in which a direct experience is transformed into learning. Roberts (2006) stated that experiential learning is cyclical in nature, which indicates learning from experience is an on-going process. Kolb's (1984) model of the experiential learning cycle includes two modes of grasping experience which include *concrete experience* and *abstract conceptualization* and two modes of transforming the experience into knowledge which include *reflective observation* and *active experimentation* (Figure 1). Learners should engage with all four modes of this cyclical process for knowledge to be created and learning to occur (Kolb, 2015). While this process is cyclical, there is no beginning or end, and learners may enter this learning process at any stage (Kolb, 2015; Roberts, 2006).

Figure 1
Model of the Experiential Learning Cycle



Note. Reprinted from *Experiential Learning: Experience as the Source of Learning and Development* (2nd ed.), by David A. Kolb, ©2015. Reprinted by permission of Pearson Education, Inc., New York, New York.

Kolb (2015) explained the experiential learning cycle is an oversimplified explanation of learning, and that learning is the process of knowledge creation. Dewey (1938, p. 39) stated, “experience does not go on simply inside a person.” Rather, a transaction between a person and their learning environment must take place to constitute a learning experience (Kolb, 1984). Dewey (1938) continued by explaining experiences are objective in the sense that previous experiences can affect how one perceives and understands subsequent experiences. Accordingly, educators should recognize their responsibility of controlling the environing conditions when providing learning experiences which lead to educational growth (Dewey, 1938).

While Roberts (2006) agreed experiential learning can be defined as a *process*, it can also be defined by the *context* in which it occurs. Learning does not occur in a vacuum and is dependent upon the context in which it occurs (Dewey, 1983). Roberts (2006) proposed four continuums in which to define the context of a learning experience: the level, the duration, the setting, and the intended outcome. The *level* of an experience can be defined as abstract or concrete. The *duration* of an experience occurs on a continuum ranging from seconds to years. The *setting* in which an experience can occur can be formal, non-formal, or informal. Finally, the *intended outcome* of an experience can be dissemination, internalization, identification, participation, or exposure (Roberts, 2006).

Reflective Observation

Reflection is an important facet of experiential learning, and is defined as the internal process in which an experience is transformed into learning (Kolb, 2015). Kolb (2015) explained reflection is not emphasized enough as a crucial component for learning and development to occur. Schön (1983) created the concepts of reflection-in-action and reflection-on-action. Reflection-in-action serves as an active evaluation where learners reflect during an experience, whereas reflection-on-action encourages learners to reflect after an experience occurs (Schön, 1983). Reflection-in-action is compared by Schön (1983) to knowledge-in-action. Reflection which occurs *in the moment* is classified as reflection-*in*-action and allows one to convert performance to knowledge. Reflection on an experience which has already transpired is classified as reflection-*on*-action and depends on intuitive knowledge which stems from an internal representation of one's experience (Schön, 1983). Schön (1983) emphasized the relationship which exists between thinking and action by stating, "reflection enabl[es] the inquirer to criticize, test, and restructure his understandings" (p. 277).

In a study by Lamm et al. (2011), it was found that while various learners may prefer to reflect differently, reflection is integral to learning when teaching experientially. Therefore, it is equally important for instructors to dedicate time and attention to reflection activities (Lamm et al., 2011). In fact, Phan (2013) found a statically significant relationship between higher-order refection and student academic performance. Andrusyszyn & Davie (1997, p. 123) emphasized this relationship by stating, "reflection and learning share a symbiotic relationship." As the scope of student reflection expands, so does the scope of learning (Andrusyszyn & Davie, 1997). Educators should ultimately recognize the important role reflection plays within the learning process, and provide their students with opportunities to reflect (Andrysyszyn & Davie, 1997; Blackburn et al., 2015; Lamm et al. 2011; Phan, 2013).

Abstract Conceptualization

Abstract conceptualization is a learner's ability to grasp knowledge through the creation of concepts and integration of observations into logical theories (Kolb, 2015). When grasping knowledge through abstract conceptualization, ones' working memory becomes stimulated and situates new knowledge and facts with those which already exist. This function, noted as intelligence, requires emotional and mechanistic aspects of learning to occur (Kolb, 2015).

Previously learned and relevant concepts are foundational to new learning and knowledge retention (Ausubel, 2000). The *level* of abstraction influences learning and developmental readiness. For example, more abstract, higher-order, and complex topics have implications for intellectual ability. Therefore, the level of abstraction also influences knowledge retention and thinking processes. Learning and retention of content knowledge is hierarchal, and the level of abstraction one receives plays an important role in the hierarchy (Ausubel, 2000). This perspective aligns with Kolb's (2015) belief that the quality of an experience is more important than the order in which the learning process occurs.

Purpose and Objectives

The purpose of this study was to examine the effects of reflection type and abstraction order on content knowledge and content knowledge retention when teaching experientially. This study aligned with research priority four of the *National Research Agenda* (Edgar et al., 2016) and included six research questions:

1. What effect does an interaction between abstraction order and reflection type have on content knowledge?
2. What is the variance in content knowledge attributed to abstraction order?
3. What is the variance in content knowledge attributed to reflection type?
4. What effect does an interaction between abstraction order and reflection type have on content knowledge retention?
5. What is the variance in content knowledge retention attributed to abstraction order?
6. What is the variance in content knowledge retention attributed to reflection type?

The following null hypotheses were created for statistical analysis purposes:

H_0 1: There is no variance in content knowledge scores due to the interaction of abstraction order and refection type.

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

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

H_0 4: There is no variance in content knowledge retention scores due to the interaction of abstraction order and reflection type.

H_0 5: There is no difference in the overall mean content knowledge retention scores between reflection-in-action and reflection-on-action groups.

H_0 6: There is no difference in the overall mean content knowledge retention scores between pre-abstraction and post-abstraction groups.

Methods

Design

This experimental research study employed a 2x2 factorial design. The independent variables for this study were abstraction order and reflection type. The first dependent variable of this study was solar energy content knowledge measured by a 25-question, criterion-referenced assessment. The second dependent variable was solar energy content knowledge retention as measured by the same assessment. The population of interest for this study were secondary students, defined as grade levels nine through twelve, enrolled in agricultural education courses. This study was conducted at a rural/suburban, Florida, high school of approximately 800 students during the spring semester of 2019. Permission to conduct this study was obtained from the agriscience teacher, school administrators, and school board personnel. The agriscience course enrollment at the high school included 140 students enrolled in eight courses. Of those 140 students, 56 participated in this study.

Non-probability, convenience sampling was used to identify the participating agriscience program. Students enrolled in agricultural education at the selected high school were randomly assigned to one of four treatment groups. Institutional Review Board and parent consent was obtained for all students who participated in this study. These groups were developed based on abstraction order and reflection type. Two groups were created for abstraction order (pre-abstraction and post-abstraction), and two groups were created for reflection type (reflection-in-action and reflection-on-action). This allowed for the use of a completely randomized factorial (CRF-*pq*) 2x2 design for this study (Kirk, 1995; See Figure 2).

Figure 2
CRF-pq (2x2) Design for Random Assignment of Student Participants

	Reflection-In-Action	Reflection-On-Action
Pre-Abstraction	Treatment Group A *n* = 13	Treatment Group B *n* = 14
Post-Abstraction	Treatment Group C *n* = 16	Treatment Group D *n* = 13

Ary et al. (2010) explained the design of an experiment should aid in minimizing threats to internal validity. Ary et al. (2010) discussed 11 possible threats to internal validity. The use of random assignment in experimental design is effective in controlling for threats to validity (Ary et al., 2010). The authors explained random assignment, "operates independently of personal judgment and of the characteristics of the subjects" (Ary et al., 2010, p. 284). In this study, students were randomly assigned a number (one through four) to assign them to a group. Due to this randomization, the groups were considered statistically equivalent (Ary et al., 2010). The design of this study allowed the researchers to control for 10 of the 11 threats to validity. This experiment began with 56 participants who received all assigned treatments. However, 11 students did not complete the content knowledge retention assessment. Thus, the threat of mortality should be taken into account as a limitation of this study.

Procedures

For this study, Lab-Aids© Investigating Photovoltaic Cell kits were utilized to provide a formal, laboratory experience for learning about solar-powered energy. Students assigned to a pre-abstraction group received the laboratory experience first with the solar energy lecture/discussion session to follow. Students assigned to post-abstraction groups received the solar energy lecture/discussion session first with the laboratory experience to follow. Students assigned to a reflection-in-action group received reflection questioning from the instructor throughout the learning experience. Students assigned to a reflection-on-action group received reflection questioning from the instructor at the end of the learning experience.

Learning activities should be described by the context in which they occur (Roberts, 2006). Drawing from Roberts' (2006) four dimensions to define the context of a learning experience, the experience provided to participants was *three hours and thirty minutes* in duration. Due to the hands-on nature of the laboratory experiment, the level of this learning experience was defined as *concrete*. Experiments which occur in a classroom setting, such as this one, are defined as *formal* learning experiences. An objective of the learning experience was to facilitate learner involvement with photovoltaic cells. Therefore, the fourth and final dimension of this learning context can be defined by an intended outcome of *identification*.

The treatment was administered during one, three-hour and thirty-minute period in which students were permitted to participate by the school administrators. Four instructors, including three of the researchers and an agriscience educator, led each of the four groups concurrently in four separate classrooms. Each of the four instructors were certified agriscience teachers, and met prior to lesson delivery to review the lesson plan, PowerPoint©, and reflection guide to ensure consistency in teaching. The pre-abstraction groups (A and B) received a 50-minute lecture/discussion lesson on solar energy and photovoltaic cells first. The post-abstraction groups (C and D) received the 90-minute LabAids© Investigating Photovoltaic Cells laboratory experience first. The reflection-in-action groups (A and C) received reflection prompts throughout the agriscience laboratory experience. The reflection-on-action groups (B and D) were allowed to complete the agriscience laboratory experience without interruption, and participated in reflection at the end of the experience.

Data on content knowledge were collected with a criterion-referenced, 25 multiple-choice assessment which was administered during the final 40 minutes of the period. Assessment questions were developed using the content provided in the LabAids© teacher's guide, and to assess if the lesson's learning objectives were achieved. The assessment was also developed and administered utilizing Wiersma and Jurs (1990) eight factors for implementing assessments. A panel of experts, composed of two agricultural education faculty and three agricultural education PhD students, assessed the instrument for face and content validity. Based on their recommendations, five additional questions were added and one question's distractors were edited to ensure clarity. The assessment was administered in a classroom setting in which the participants were familiar with meeting for class. A pre-typed set of instructions were read aloud to ensure consistency across groups and to minimize student confusion. Data collection on content knowledge retention were collected utilizing the same assessment and testing environment two weeks following the students' participation in the laboratory experience.

Data Analysis

A two-way independent analysis of variance (ANOVA) was used to calculate the two main effects (abstraction order and reflection type) and the interaction effect between these independent variables (Field, 2018). Testing the effects of two independent variables on a dependent variable can be done by use of the two-way ANOVA (Field, 2018). A two-way ANOVA was run for each content knowledge scores and content knowledge retention scores.

The assumptions regarding the use of ANOVA were examined and met before the use of the statistical tool. When determining if equal variances were shared between treatment groups, Field (2018) strongly cautions against testing for homogeneity of variance using *Levene's test* for two reasons: (a) In large sample sizes, Levene's test may be over sensitive and detect significance for unimportant variables, and (b) in small samples, Levene's test often lacks enough power to detect violations of the assumption of normality. Field (2018) explained normality testing via Levene's test can be moot, no matter the sample size, due to the test's dependence upon having a large enough power base to accurately detect violations of assumptions. Further, tests of homogeneity of variance matter most with small sample sizes and unequal groups, but are less effective under these conditions. In contrast, tests of homogeneity of variance matter the least with large sample sizes and equal groups, but work best under these circumstances (Field, 2018). Zimmerman (2004) reported preliminary tests of variance can lead to incorrect statistical decisions due to their subjectivity to Type I and Type II errors. In lieu of Levene's test, Field (2018) recommended utilizing histograms and Q-Q plots to identify possible heterogeneity of variance because histograms allow for testing of skewness and kurtosis. As such, unstandardized residuals for all combinations were calculated for the dependent variable. Data were analyzed with IBM SPSS Statistics Version 26. The Kolmogorov-Smirnov test and the Shapiro-Wilk test were used to determine normality. Both tests yielded non-significant results ($D(45) = .111$, $p = .200$; $W(45) = .980$, $p = .630$). Thus, the data were deemed statistically normal. In addition to the statistical analyzes, histograms and Q-Q plots were examined to ensure normality as recommended by Field (2018).

The statistical and practical effects were both reported for the findings. An *a priori* alpha level of .05 was set to determine statistical significance by the researchers. The statistical significance was used to determine rejection or failure to reject the null hypotheses (Ary et al., 2010; Kirk, 1995). However, statistical significance should not be considered alone. The practical significance of the effect should also be considered (Ary et al., 2010). Partial eta squared was utilized to determine the practical effect size. Miles and Shevlin (2001) categorize partial eta squared effect sizes as follows: (a) 0.01 – small effect size, (b) 0.06 – medium effect size, (c) 0.14 – large effect size.

Findings

When analyzing the content knowledge test scores, the means, with standard deviations in parentheses, are as follows: reflection-in-action 41.03 (5.99), reflection-on-action 42.37 (5.35), pre-abstraction 41.47 (4.61), and post-abstraction 41.92 (6.80). A report of descriptive statistics is presented in Table 1.

Table 1

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

Type of Reflection	Order of Abstraction	*M*	*SD*	*n*
Reflection In	Pre-Abstraction	41.85	7.37	13
	Post-Abstraction	40.38	4.74	16
	Total	41.03	5.99	29
Reflection On	Pre-Abstraction	42.71	4.27	14
	Post-Abstraction	42.00	6.48	13
	Total	42.37	5.35	27
Total	Pre-Abstraction	41.47	4.61	30
	Post-Abstraction	41.92	6.80	26
	Total	41.68	5.68	56

A summary of the ANOVA is presented in Table 2. The interaction effect of reflection type and abstraction order generated an $F(1,52) = .50$, $p = .48$, observed power = .107, and was deemed insignificant. Therefore, the first null hypothesis failed to be rejected. When analyzing the main effects, type of reflection yielded an $F(1, 52) = .65$, $p = .42$, observed power = .124, and was also deemed to be insignificant. Thus, the second null hypothesis failed to be rejected. The main effect of abstraction order was statistically insignificant with an $F(1,52) = .06$, $p = .81$, observed power = .057, which resulted in failure to reject the third null hypothesis.

Table 2

Content Knowledge ANOVA Summary Table

Source	*SS*	*df*	*MS*	*F*	*p*
Abstraction	1.99	1	1.99	.06	.81
Reflection	21.60	1	21.60	.65	.42
Abstraction* Reflection	16.60	1	16.60	.50	.48
Error	1730.30	52	33.28		
Total	99052.00	56			

Means, with standard deviations in parentheses, for content knowledge retention scores are as follows: reflection-in-action 27.27 (10.56), reflection-on-action 34.69 (8.17), pre-abstraction 31.91 (11.27), and post-abstraction 30.18 (8.73). A report of descriptive statistics is presented in Table 3.

Table 3
Mean Content Knowledge Retention Test Scores for Treatment Conditions of Reflection Type and Abstraction Order

Type of Reflection	Order of Abstraction	*M*	*SD*	*n*
Reflection In	Pre-Abstraction	29.82	8.41	11
	Post-Abstraction	24.73	12.21	11
	Total	27.27	10.56	22
Reflection On	Pre-Abstraction	38.50	4.44	12
	Post-Abstraction	30.55	9.43	11
	Total	34.69	8.17	23
Total	Pre-Abstraction	31.91	11.27	23
	Post-Abstraction	30.18	8.73	22
	Total	31.07	10.03	45

A summary of the ANOVA for content knowledge retention scores is found in Table 4. The interaction effect yielded an $F(1, 41) = 5.93$, $p = .02$, observed power = .662. Accordingly, the fourth null hypothesis was rejected. The practical significance of this difference was calculated using a partial eta squared per Miles and Shevlin (2001). The effect size for the difference was .13 which Miles and Shevlin (2001) defines as *medium*. The main effect of reflection type was found to be significant with an $F(1, 41) = 7.33$, $p = .01$, observed power = .753. Thus, the fifth null hypothesis was rejected. The effect size was .15 which is defined as *large* by Miles and Shevlin (2001). The main effect of abstraction order was found to be statistically insignificant and yielded an $F(1, 41) = .29$, $p = .60$, observed power = .082. This resulted in failure to reject the sixth and final null hypothesis.

Table 4
Content Knowledge Retention ANOVA Summary Table

Source	*SS*	*df*	*MS*	*F*	*p*
Abstraction	23.03	1	23.03	.29	.60
Reflection	590.49	1	590.49	7.33*	.01[a]
Abstraction* Reflection	477.96	1	477.96	5.93*	.02[b]
Error	3303.55	41	80.57		
Total	47860.00	45			

Note. [a]Effect size = .15 per η_p^2; [b]Effect size = .13 per η_p^2 (Miles and Shevlin, 2001); *p < .05.

A visual model which displays the treatment groups and their respective content knowledge retention score means, with standard deviations in parentheses, is found in Figure 3. Treatment group A (reflection-in-action and pre-abstraction) had a mean of 29.82 (8.41). Treatment group B (reflection-on-action and pre-abstraction) had a mean of 38.50 (4.44). Treatment group C (reflection-in-action and post-abstraction) had a mean of 24.73 (12.21). Treatment group D (reflection-on-action and post-abstraction) had a mean of 30.55 (9.43).

Figure 3
Mean Content Knowledge Retention Test Scores by Treatment Group

	Reflection-In-Action	Reflection-On-Action
Pre-Abstraction	Treatment Group A $M = 29.82$ (8.41)	Treatment Group B* $M = 38.50$ (4.44)
Post-Abstraction	Treatment Group C $M = 24.73$ (12.21)	Treatment Group D $M = 30.55$ (9.43)

Note. $^*p < .05$.

Conclusions

The lack of simple main effects indicate reflection type and abstraction order are independent of one another when analyzing student content knowledge gains. This conclusion indicates neither the method in which students reflect nor the order in which they receive abstraction affects students' ability to attain content knowledge. While this conclusion is congruent with DiBenedetto et al. (2017), it is incongruous with Baker et al. (2014) who found reflection-in-action can positively affect student content knowledge attainment. This finding is also consistent with Kolb (1984) and Roberts (2006) who defined the experiential learning process as a cycle with no defined starting point.

The statistically significant interaction effect indicates reflection type and abstraction order are dependent upon one another when analyzing student content knowledge retention. This indicates reflecting-on-action when students receive abstraction prior to a learning experience could positively affect students' ability to retain content knowledge. The previous researchers (Baker et al. 2014; DiBenedetto et al., 2017) did not examine reflection type and abstraction order on student content knowledge retention; therefore, this is a new finding within agricultural education. This finding adds to the assertion by Ausubel (2000) that in addition to the level of abstraction one receives, pre-abstraction could be beneficial for knowledge retention when coupled with reflection-on-action.

Recommendations for Research

Baker et al. (2014) recommended to achieve a power base of .80, this study should be conducted with a minimum of 76 participants. This research fell short of that goal by 20 participants. Therefore, it is recommended future replications of this research strive to achieve a sample size of 76 participants or more. While this study analyzed student content knowledge and content knowledge retention, there are other dependent variables which could be considered. Future studies could analyze the effects of abstraction order and reflection type on other dependent variables such as students' problem-solving skills, logical reasoning abilities, and others.

Future research which also analyzes content knowledge retention should have a broader scope to include the regression of content knowledge over time. For example, in this study, if a treatment group achieved a high, post-test score, but a low, deferred, post-test score then that group would have a lower rate of knowledge retention than a treatment group who achieved a low, post-test score and a similarly low, deferred, post-test score. Multivariate research, and the use of a repeated measures ANOVA, should be used to analyze knowledge retention rates over time (Field, 2018; Kirk, 1995). To achieve this, it is necessary to have the same group members in each data collection point over time. This study did not accomplish this due a lack of control for mortality and the blinded nature of the testing instrument, thus, making it difficult to remove participants who did not participate in both assessments. Future research which includes this procedure could have stronger arguments as to which variables, if any, impact student content knowledge retention.

The context of the learning experience in this study was defined with an intended outcome of *identification* per Roberts (2006). While this study analyzed the order of abstraction on content knowledge and knowledge retention gains, Ausubel (2000) purported the level of abstraction is fundamental to learning and retention. Future research should consider learning contexts with higher levels of intended outcomes and their effects on knowledge and retention. For example, if a learning experience provides abstraction that prompts complex, higher-order thinking, what implications might this have for student knowledge and retention?

The last recommendation for future research is one of practicality. Those wishing to conduct this study at the secondary school level should consider the amount of time and preparation involved. Attaining IRB approval, parental consent, and school administrative permission when conducting experiments with secondary school students may take multiple weeks. Accordingly, researchers should prepare to conduct similar studies well in advance of school holidays and semester breaks.

Recommendations for Practice

Experiential learning is foundational to agricultural education and is widely used by agricultural educators (Phipps et al., 2008; Roberts & Ball, 2009). This study supports the notion that the agricultural instructor plays a crucial role in facilitating reflection when teaching experientially (Baker et al., 2012). This study indicates those who implement experiential learning should provide intentional reflection opportunities for their students – regardless of reflection type. Additionally, practitioners should note the cyclical nature of experiential learning, and recognize while abstraction is an important part of the process, the order in which it occurs has little to no bearing on student content knowledge gains (Kolb,1984; Roberts, 2006). This study, however, would indicate practitioners who are interested in knowledge retention outcomes should implement purposeful reflection-on-action techniques when delivering abstract conceptualization prior to an experience. Faculty members who lead pre-service teacher preparation programs should teach about how the theory of experiential learning informs the process (Roberts, 2006). Intentionality matters when planning learning experiences to include purposeful reflection and effective abstraction techniques.

Experiential learning is fundamental to agricultural education, and it is a teaching methodology frequently used by agricultural educators (Baker et al. 2012; Phipps et al., 2008; Roberts 2006; Roberts and Ball, 2009). However, not all agriculture teachers utilize holistic experiential learning (Shoulders & Myers, 2013). Therefore, agricultural educators should receive training on operationalizing the theory of experiential learning into practical teaching settings. Pre-service teacher education programs should emphasize the importance of including all four components of experience, abstraction, reflection, and experimentation when teaching experientially.

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