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STEM Knowledge, Learning Disabilities and Experiential Learning: Influences of Sequencing Instruction

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Abstract

Career and technical education (CTE) courses, including agricultural education courses, are home to a disproportionately large number of students with learning disabilities. Agricultural education has been sought as a potential solution to teaching abstract STEM concepts through experiential learning methods. Abstract concepts are noted in the literature as particularly difficult for students with learning disabilities to grasp. This study was designed to describe the changes in pretest and posttest scores on STEM content tests for students when accounting for their preference for grasping information through experiential learning theory and their learning disability classification. When instruction was sequenced to match student learning preference, change scores for students with learning disabilities were increased. When instruction was opposite student preference, students with learning disabilities had lower change scores than those without a learning disability classification. Results highlight the importance of sequencing instruction for both students with and without learning disabilities. Examining students through experiential learning theory may provide a platform for mitigating the effects of learning disabilities on student achievement.

Keywords: STEM, experiential learning; learning disabilities; sequencing, differentiation

Introduction

All students are unique, each has an individual aptitude and capacity for bringing in, storing, and retaining information (Sousa, 2011). A universal concept found in almost all models of student learning is the level of each student's ability to process information (Bender, 2007). Accounting for individual learning ability in education is essential within an examination of how students learn. The concept of differentiated instruction, as examined by Tomlinson (2014) is based on the premise that each student is unique in their educational requirements, and should therefore be instructed in a manner which best meets their individual needs.

In the United States, legislation exists providing accommodations and modifications to the instruction and assessment of students who are classified with a condition which inhibits their learning. The origin of learning disability classification can be traced to Public Law 94-142, The Education Act for All Handicapped Children Act of 1975 (EHA). This educational policy outlined the requirements for instruction related to students with learning disabilities, including free appropriate public education for children three to 21 years old, protecting the rights of children

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with disabilities and their parents, Individualized Education Plans (IEPs), and providing a least restrictive environment for learning. EHA also provided provisions for federal funding to meet the aims of the new policy (Osborne & Russo, 2014). This legislation has been updated and revised to include more specific information related to how to ensure the needs of special education students in the country are met (Osborne & Russo, 2014).

The very definition of a learning disability (LD) lends itself to the importance of using learning disability status as a factor in understanding student achievement. Bender (2008) defined a learning disability as "a condition giving rise to difficulties in acquiring knowledge and skills to the level expected of those of the same age, especially when not associated with a physical handicap" (p. 18). Although there are large differences in the types of learning disabilities classified by federal legislation, researchers have found that collectively, students classified with an LD have lower test performance and GPA than those without learning disabilities, even when the accommodations of an IEP are in place (Hampton & Mason, 2003).
One of the most common manifestations of learning disabilities is difficulty converting abstract knowledge into applied knowledge (Bender, 2007). Abstract conversion is an important factor for STEM education, as many of the concepts are incredibly abstract when presented without context (Stone, 2011).

In STEM fields, there are known differences in the performance of students with learning disabilities on STEM assessments (Boaler, 1998; Kieran, 1992; Woodward & Montague, 2002). This examination has led researchers to conclude that there may be a large advantage to allowing students with learning disabilities to approach abstract concepts, like those in STEM education, through applied means (Furner & Kumar, 2007; Stone, 2011). Bender (2008) outlined the importance of ensuring educational researchers are mindful of the ways in which students with learning disabilities learn content and perform on assessments. Bender (2007) also shared the critical need to provide LD students with differentiated instruction that allows them to experience education in the teaching strategy most closely aligned with their capacity for learning. Cognitive sequencing is a way to differentiate instruction and provide assistance for students with learning disabilities, especially related to presenting information using the cognitive sequence students prefer to grasp information in first (Woodward & Montague, 2002).

CTE courses are home to a disproportionately large number of students with learning disabilities (Wagner, Newman, & Javitz, 2015). In a national study of more than 9,000 public high school students with learning disabilities, 96.0% had taken at least one CTE course during high school (Wagner, et al., 2015). To further demonstrate the broad-scale involvement of LD students in CTE courses, they shared that CTE courses accounted for nearly one-fifth (19.7%) of all high school credits earned by learning disabled students (Wagner, et al., 2015). By comparison, CTE courses only accounted for 12.8% of the total credits earned by all high school students combined (Wagner, et al., 2015). The most accessible factor for classifying LD students is the presence of an IEP on file with the school (Bender, 2008). It is important to note that learning disabilities are varied and that each level and type of LD has a different potential effect on student academic performance. The presence or absence of LD classification is not a perfect indicator of student academic ability, however, it can be useful in classifying students who typically need supplemental educational assistance, and therefore, have learning differences from their peers (Bender, 2007).

Individualizing learning is the goal of education for students both with and without classified learning disabilities (Tomlinson, 1999). Some researchers prescribe the classification of learning styles as a method through which to differentiate instruction (Brokaw & Merz, 2000; Claxton & Murrell, 1987; Coffield, Moseley, Hall, & Ecclestone, 2004a, 2004b; Duff, 2004; Dunn & Dunn, 1989; Felder & Silverman, 1988; Fleming, 2001; Gregorc, 1979; Kolb, 1984, 2015;

Tomlinson, 1999). Sousa (2011) discussed the varying acceptance of learning styles within academia and neuroscience and concluded: "there is little argument that people have various internal and external preferences when they are learning" (p. 59).

The sequence of information is another consideration that could impact learning (Reigeluth, 2013). Many theories of instruction do not include a preferred sequence for the presentation of concepts, however, there are several that give specific outlines for the sequencing of information. The concepts of sequencing instruction are most commonly related to the sequencing of critical thinking skills or presenting information which builds from basic to more advanced concepts (Reigeluth, 2013). Several prominent theories include sequencing based on the complexity level of concepts. Most of these theories prescribe a movement through concepts from basic to advanced. Landa (1983) proposed an exception to the 'basic-first' learning theories and promoted a theory of instruction in which students were first exposed to the highest order thinking skills, and then learned the abstract components which they were comprised of. An examination of current trends in instructional methods, including problem-based learning, and inquiry-based learning reveals that sequencing instruction beginning with a concrete experience is gaining popularity in educational circles (Reigeluth, 2013).

Kolb's (1984) experiential learning theory (ELT) has four distinct modes of learning, organized around two dimensions of grasping and transforming information. Kolb (2015) explained the structural process of the learning cycle by describing the two adaptive dialects which are rooted in Piaget's (1970) aspects of thought and their eventual resolution. The abstract/concrete dimension deals with the grasping or "taking hold" of experience, through either reliance on abstract conceptualization (comprehension) or concrete experience (apprehension), both related to the dialectic of prehension (Kolb, 2015). In contrast, the active/reflective dimension is related to the transformation of the experience, and can be seen as the conflict between active experimentation (extension) and reflective observation (intention). Combining both the prehension dialectic and the transformation dialectic results in building knowledge (Kolb, 2015).

Within the ELT framework, it may be easy to assume that Kolb suggested both a starting and ending point for the cycle. However, Kolb's view of the sequence for the four learning modes is not prescriptive. He states that the cycle may be entered at any point, and gives only a caution that the stages should be followed in sequence from wherever the learner begins (Kolb, 2015). Very rarely does the concept of a particular sequence related to the learning cycle appear in ELT literature. Cognitive sequencing in this study was an examination of the prehension dimension of grasping information. The experimental treatments in this research were based on the dual dialectics of apprehension, which is grasping through experience, and comprehension, which is grasping through abstraction (Kolb, 2015).

Of special note in this study were potential differences in cognitive stages of individuals with learning disabilities. Kolb shared that experiential learning only has learning implications for people who have the cognitive ability to relate learning to experience (Kolb, 1984, 2015). As a connection, Piaget (1972) put forth the stages of development related to the ability of a person to grasp abstractions, as shown in Table 1.

Table 1

Piaget's (1972) Stages of Cognitive Development

Stage	Age	Description
Sensorimotor	0-2 years	Exploration through direct sensory input and motor contact
Preoperational	2-6 years	Symbols may be used to represent objects, lack of logical reasoning
Concrete Operational	7-12 years	Logical thought is present related to concrete objects
Formal Operational	12+ years	Abstract reasoning and hypothetical thinking are evident

Piaget (1972) suggested individuals age seven to twelve develop logical thoughts based on the relationship between concrete objects. Further, Piaget (1972) suggested that formal operational thinking, in which abstract reasoning and hypothetical thinking are evident, does not materialize in most people until after age twelve, and may not materialize at all in many individuals. Concrete and abstract concepts may not be clearly defined without targeted concrete examples for students with learning disabilities, and many will never reach the formal operational level of cognitive development (Bender, 2008).

Identifying preferences for grasping new experiences through apprehension as opposed to comprehension could provide important information about how cognitive sequencing of information might play a role in student learning, especially for LD students. It would stand to reason that students who have a preference for grasping information through apprehension could perform higher on units with STEM integration when the concrete experience was presented as the initial point in the learning cycle. By contrast, students who show a preference for grasping experience through comprehension may grasp STEM concepts more readily when the abstract conceptualization stimulus was presented as the beginning point for the learning cycle.

Theoretical/Conceptual Framework

Designing this study required us to draw from theories in two different areas. First, we needed to rely on a theoretical basis to help frame the factors which drive learning in individual students. Next, we relied on theory to assist in the development and process of sequencing instruction. A combination of foundational theories in both areas led us to develop the conceptual framework we used to guide this experiment.

One of the pioneers who suggested factors contributing to student learning was John Carroll, who outlined his model for school learning in 1963. Carroll (1963) proposed aptitude as the time needed for individual students to learn a specific task, and listed opportunity to learn, perseverance, quality of instruction, and ability to understand instruction as factors which would impact student achievement. Numerous scholars have contributed to this seminal model, adding factors including learning preferences, perseverance, motivation, home environment, and school climate (Darling-Hammond & Bransford, 2005; Silins & Mumford, 2002; Stringer, Christensen & Baldwin, 2009).

The model used to frame the sequencing portion of this study was Kolb's (1984, 2015) experiential learning theory. Kolb's model is a "dynamic view of learning based on a learning cycle driven by the resolution of the dual dialectics of action/reflection and experience/abstraction"

(Kolb, 2015, pp. 50-51). The cyclical process of learning as a relationship between the four modes of active experimentation (AE), concrete experience (CE), reflective observation (RO) and abstract conceptualization (AC) are shown in Figure 1 (Kolb, 1984, 2015). This study was developed using experiential learning theory to examine student preferences for grasping information and to purposefully sequence information as it was presented to students.

The resulting conceptual model for this study is shown in Figure 1. The model relies on Gagne's (1965) theory of instruction to guide instructional factors affecting learning. Experiential learning theory, as outlined by Kolb in 2015, was used as the theory guiding instruction for presenting the stimulus to students, with lessons accounting for all four of Kolb's learning modes.

Through this model, student performance was tested using experimental curricula developed to standardize the events of instruction as outlined by Gagne (1965), manipulating only the cognitive sequence with which information was presented based on Kolb's (1984) experiential learning model. Resulting changes in learning between dependent measures were examined in relation to student factors affecting learning or manipulation of cognitive sequence.

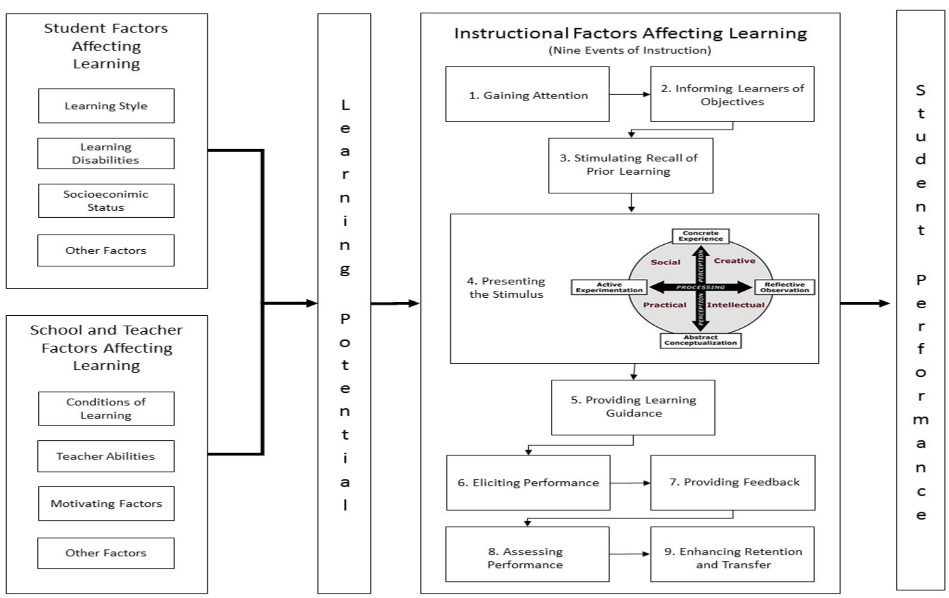

Figure 1. Conceptual model of student learning and sequencing instruction based and Kolb's (1984) experiential learning theory.

Purpose and Objectives

The purpose of this portion of a larger study was to examine learning disability classification status as a variable related to a preference for grasping information through experiential learning theory. To accomplish this purpose, the following objectives were used to frame the examination:

1. Describe the *KLSI* scores for participants with and without learning disability classification.
2. Describe the pretest and posttest scores for students with and without learning disability classification.

3. Describe the change in pretest and posttest scores for students with and without learning disability classification when information is presented in a sequence matching student learning preference.

Methods

This study was conducted as a quasi-experimental cross-over examination of the factors related to student learning on STEM content assessments in agricultural education. The crossover design was chosen based on the ability of this design to provide an examination of the effects of two separate treatments on each participant, in an effort to decrease threats to external validity (Shadish, Cook, & Campbell, 2002). The dependent variables in this study were the change scores from pretest to posttest on two researcher-developed assessments for science-infused units of instruction. Independent variables of interest for this portion of the study included learning disability classification and preference for grasping information through either apprehension (CE) or comprehension (AC).

This study included participation from students enrolled in a freshman-level introduction to agriculture course at four high schools (N = 121). A total of n = 111 students completed the consent and assent process. Two separate week-long units of instruction were created, one in water science and one in soil science. Each of the content area units was created with two cognitive sequences, one with lesson plans presenting each new concept through concrete experience and moving to abstract conceptualization, and another complementary unit with lesson plans presenting each new concept first through abstract conceptualization and then progressing to concrete experience activity. Each test unit (site) received both content areas, and sites were randomized as to which content area and cognitive sequence they would receive first. Site one was selected as the control and received no experimental treatments. Identical pre and post-test assessments were given to students for each content area, regardless of the cognitive sequence of instruction. A group of experts in agricultural education, experiential learning theory, and curriculum planning assisted in the preparation and development of the treatment curricula. Instructors at each school were trained in the utilization of the curriculum models provided and signed agreements of compliance to verify their instruction of the units exactly as presented in the trainings.

Unit assessments were developed to directly assess each of the unit objectives with exam questions at multiple levels of cognition. Reliability coefficients (*KR20*) were 0.75 for the water science pretest and 0.78 for the water science posttest. For the soil science tests, the resulting reliability coefficients (*KR20*) were 0.81 for the pretest and 0.86 for the posttest. Reliability coefficients derived from a *KR-20* analysis for teacher-made tests are considered to be acceptable at a level of 0.65 or higher (Frisbie, 1988), thus the reliability of both unit assessments were deemed acceptable for the intended purpose of this study. To determine the learning style preference for respondents in regard to grasping information, *KLSI v. 3.1* instrument was used.

Validity of the KLSI v. 3.1 has been widely established for use in the field of education (Kolb & Kolb, 2005). Validity was determined to be acceptable for the purposes of this study. Previous measures of reliability for the four learning modes included in the KLSI range from α = 0.77 to α = 0.84 (Kolb & Kolb, 2005). Post hoc reliability ranged from α = 0.81 to α = 0.92. As such, reliability was determined to be suitable for use in this study.

To collect the information related to learning disability classification, teachers provided a verification of student LD based on the presence of an IEP requiring instructional modifications. In one site, LD classification was not readily available to teachers. We contacted school district personnel who were able to provide the data directly. Resulting data were analyzed using IBM

SPSS © version 23. Analyzed data were restricted to an examination of the descriptive statistics for each group, as group sizes were not large enough to warrant the use of inferential statistics.

Subject Characteristics

Information regarding the schools participating in this study is shown in Table 2. This information shows each school along with the available data for all Texas high schools as reference. All sites met state standards for academic programming. Enrollment ranged from 202 students at site two to 1599 enrolled at site four. Ethnicity in the school population varied, although the proportion of Hispanic students in each site was lower than the state average of 52%. The percentage of the graduating class at each site who were enrolled in special education programming is widely varied, from 4.2% of graduating seniors at site three, to 20.0% of graduating seniors at site two.

Table 2

Descriptions of Schools Participating in Study

Characteristic	Site 1	Site 2	Site 3	Site 4	State
2015 Accountability Rating	Met Standard	Met Standard	Met Standard	Met Standard	--
Enrollment	606	202	1732	1599	--
Ethnic Distribution %					
African American	9.7	11.9	13.6	23.2	12.6
Hispanic	23.1	32.7	22.5	46.1	52.0
White	64.0	53.0	51.1	29.4	28.9
American Indian	0.3	0.0	0.3	0.1	0.4
Asian	0.2	0.0	8.6	0.3	3.9
Pacific Islander	0.0	0.0	0.0	0.1	0.1
Two or More Races	2.6	2.5	3.8	1.0	2.0
Low SES %	36.0	39.1	33.3	64.8	58.8
At-Risk %	46.7	37.6	30.4	35.2	51.2
Special Education Graduates %	14.1	20.0	4.2	7.5	--

Characteristics of study participants by site were also examined and are listed in Table 3. Overall gender of participants was nearly equally split between males (51.2%) and females (48.8%). It is interesting to note similarities in ethnic distribution between school data and participants, all of whom were enrolled in agricultural education courses.

Table 3

Demographic Information of Participants

	Site 1		Site 2		Site 3		Site 4		Total	
Characteristic	*F*	%	*f*	%	*f*	%	*f*	%	*f*	%
Gender										
Male	11	61.1	19	51.4	18	58.1	14	40.0	62	51.2
Female	7	38.9	18	48.6	13	41.9	21	60.0	59	48.8

Table 3
Table 3

Demographic Information of Participants Continued…

Ethnic Distribution										
White-non-Hispanic	12	66.7	15	40.5	14	45.2	17	48.6	58	47.9
Hispanic	3	16.7	14	37.8	9	29.0	12	34.3	38	31.4
Black	3	16.7	6	16.2	8	25.8	5	14.3	22	18.2
Asian	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Native American	0	0.0	0	0.0	0	0.0	1	2.9	1	0.8
Pacific Islander	0	0.0	0	0.0	0	0.0	0	0	0	0.0
Two or More Races	0	0.0	2	5.4	0	0.0	0	0	2	1.7

Note: due to rounding, all values for a site may not equal 100%

Participant characteristics were also examined in a relationship to the independent variables of interest in this study. Related to learning disability classification, $n = 35$ (28.9%) of participants were identified as having a learning-based IEP, while $n = 86$ (71.1%) were not classified with a learning-based IEP. There was a much higher proportion of students ($n = 85$) who showed a preference for grasping information through apprehension than those who preferred to grasp information through comprehension ($n = 36$). Independent variable frequencies and percentages are listed by site in Table 4.

Table 4

Descriptions of Independent Variable Characteristics by Site

	Site 1		Site 2		Site 3		Site 4		Total	
Characteristic	*F*	%	*f*	%	*f*	%	*f*	%	*f*	%
Learning Disability										
IEP	5	27.8	7	18.9	13	41.9	10	28.6	35	28.9
No-IEP	13	72.2	30	81.1	18	58.2	25	71.4	86	71.1
Grasping Preference										
Apprehension (CE)	10	55.6	30	81.1	18	58.1	27	77.1	85	70.2
Comprehension (AC)	8	44.4	7	19.9	13	41.9	8	22.9	36	29.8

Findings

Site one served as the control in this experiment. This site did not receive the experimental treatments, therefore the site one students ($n = 18$) were not included in the analysis related to change scores for STEM unit assessments. The total results of the *KLSI* for participants receiving treatments, separated based on their learning disability classification, are shown in Table 5.

Table 5

KLSI Scores for Participants Based on Learning Disability Classification (n = 103)

	LD (n = 30)				Not LD (n = 73)			
Construct	*Min*	*Max*	*M*	*SD*	*Min*	*Max*	*M*	*SD*
Abstract Conceptualization	15	38	27.90	4.67	17	44	27.21	6.86
Concrete Experience	17	40	29.50	5.51	16	45	27.21	5.48

Table 5

KLSI Scores for Participants Based on Learning Disability Classification (n = 103) Continued…

Active Experimentation	17	45	30.57	7.39	16	46	33.38	7.92
Reflective Observation	17	42	32.03	5.61	17	45	32.21	6.30
Grasping (AC-CE)	-18	17	2.37	7.81	-22	21	1.97	8.37
Transforming (AE-RO)	-13	25	2.50	9.76	-22	23	3.15	11.21

Note. Calculated scores can range from 12 – 48 on learning modes and -36 to +36 on dimensions. Equal balance between ends of the continuums for transforming and grasping experience dimensions is set at +7 (Kolb & Kolb, 2013).

Student preferences for learning based on apprehension or comprehension were similar for those with and without learning disability classification. Preferences for grasping information are shown in Table 6.

Table 6

Student Preferences for Grasping Through Apprehension (CE) or Comprehension (AC)

		Apprehension Preference		Comprehension Preference	
LD Classification	*f*	*f*	%	*f*	%
LD	30	22	73.3	8	26.7
No LD	73	53	72.6	20	27.4
Total	103	75	72.8	28	27.2

Students with learning disabilities had lower scores on the pretest for both the water science and soil science units than those students without a learning disability. Pretest scores are shown in Table 7.

Table 7

Mean Pretest Scores for Water Science and Soil Science Units by Learning Disability Classification

LD Classification	*n*	Water Science Unit *M*(*SD*)	Soil Science Unit *M*(*SD*)
LD	30	17.*70(16.44)*	16.16(*14.58)*
No LD	73	23.*00(18.95)*	19.61*(14.61)*
Total	103	21.46*(18.42)*	19.04*(16.27)*

Changes in score from pretest to posttest were examined related to student learning disability classification and student preference for grasping information. Students with learning disabilities showed larger changes in scores when the information was presented in the sequence matching their learning preference. Results for change scores and sequence of unit are shown in Tables 8 and 9.

Table 8

Change Scores for Water Science Unit Based on Sequence of Unit, Match to Learning Preference, and Learning Disability Classification

LD Classification	*n*	Sequence of Unit Matched to Preference *M*(*SD*)	*n*	Opposite of Preference *M*(*SD*)
LD	13	63.38*(17.31)*	17	24.94*(19.95)*
No LD	20	63.65*(21.19)*	53	36.92*(17.46)*
Total	33	63.55*(19.75)*	80	31.44*(18.11)*

Table 9

Change Scores for Soil Science Unit Based on Sequence of Unit, Match to Learning Preference, and Learning Disability Classification

LD Classification	*n*	Sequence of Unit Matched to Preference *M*(*SD*)	*n*	Opposite of Preference *M*(*SD*)
LD	17	55.53*(18.54)*	13	28.00*(18.19)*
No LD	53	60.32*(17.68)*	20	34.65*(14.20)*
Total	80	59.16*(18.01)*	33	32.03*(16.32)*

For the water science unit, when the instruction was matched to preference, student change scores were similar between students with and without an LD classification. When the water science unit was taught to students in the sequence opposite of their preference, change score means varied between groups. Change scores for all groups of students were larger when the sequence of the soil science unit matched their preference. Change scores were lower for this unit of instruction across all groups than in the water science unit.

Conclusions/Discussion/Implications

All students showed increases in change scores when the information was delivered in the sequence matching their learning preference. When units were presented in the sequence opposite student preferences, students with learning disabilities had change scores that did not match their peers without learning disabilities. Although the results of this exploratory study are limited to descriptive analysis, several findings warrant further discussion.

More students had a preference for grasping information through apprehension than comprehension. This fact was especially true among students with learning disabilities. Students with learning disabilities likely benefit from enrollment in an agricultural education course that focuses on providing concrete experiences for grasping abstract concepts. By this token, it is promising that agricultural education courses are within the CTE area, which have increased proportions of students with learning disabilities (Wagner, et al., 2015). Students in agricultural education are able to experience the experiential learning cycle as a foundational tenet of their instruction (Roberts, 2006). Of course, students can only fully realize the benefits found from cognitive sequencing through ELT in agricultural education if agricultural educators have the skills required to teach using a full ELT model. We recommend teacher educators ensure both preservice and in-service teachers are instructed on the proper integration and use of all four components of the ELT cycle through preservice instruction and professional development training.

Many of the concepts in STEM education are abstract in nature (Maltese, Potvin, Lung, & Hochbein, 2014), and the hands-on nature of agricultural education and other CTE courses have been seen as a platform for delivering these concepts (Stone, 2010). For students who prefer to grasp information through apprehension, the presentation of abstract concepts through abstract conceptualization may not provide the stimulus they need to transform the information. This is especially true for students with learning disabilities who prefer to grasp information through apprehension (Kolb, 2015). These students may be facing twice the challenge when STEM concepts are presented beginning with comprehension; they are developmentally unable to process abstractions, and they prefer to bring in information through concrete experience. Helping these students succeed requires not only attention to providing quality instruction with purposeful concrete experiences, but may also require differentiation of instruction to ensure students are presented information in a sequence which allows them to contextualize abstract concepts.

Sequencing instruction based on individual student preferences for grasping information has close ties to the literature related to differentiated instruction. Tomlinson (1999) pointed out the importance of tailoring educational practices to meet the needs of each student. The findings of this study give an example of just how critical differentiated instruction is when dealing with LD students who are tasked with learning STEM concepts in agricultural education classes. This study serves as an entry point for agricultural educators to differentiate in a new way. By using learning styles, agricultural educators may be able to capitalize on the applied nature of their content and deliver differentiated content which helps all students succeed. Based on the evidence collected in this study, teachers may be able to amplify that success in students who struggle, thus creating a more level playing field for students which have a noted disadvantage in the current educational system.

Because all of the students in this study were enrolled in general education courses, it is likely that the students with learning disabilities in this study required only minor modifications to instruction. It is a limitation to this study that individuals with learning disabilities could not be identified based on their specific accommodation plans. Students with preferences for grasping through both apprehension and comprehension exist in an agricultural education classroom, so which of the cognitive sequences is better suited for development of curriculum materials? Perhaps rather than looking at the sequence as an either-or concept, the answer would be to include both sequences within units in order to ensure the needs of all students are met. This small change to educational methods may have broad-reaching effects, not only for students without learning disabilities but for all students in agricultural education classrooms.

The results of this study allow us to make several recommendations for school-based agricultural educators. Careful attention should be paid during the design of instruction in agricultural education to ensure that students are receiving exposure to the complete learning cycle as defined through ELT. This has wide-reaching implications for the field. In addition, vendors of curriculum materials should use the learning cycle as a model with which to build lessons and develop curricula. We also recommend using the *KLSI* or similar instrument to determine student preferences for grasping experience. Results of these assessments should be used to guide instructional procedures toward the specific needs of classes and/or students.

Additional recommendations exist for teacher educators and those involved in providing ongoing teacher support. Pre-service teachers should be made aware of the potential effects of cognitive sequencing on student learning. They should be given the opportunity to develop lessons which are not sequenced in a traditional AC to CE format. If preservice teachers are preparing to meet the needs of all their students, they should be prepared for students who prefer to grasp information beginning with a concrete experience. In this study, more students preferred grasping via apprehension over comprehension. Allowing preservice teachers the opportunity to familiarize themselves with how to present information which will best reach the majority of their students is critical in their preparation. In addition to helping preservice teachers develop their own cognitively sequenced units, they should also be instructed on methods for modifying the cognitive sequence of existing curriculum materials. Most available curricula are presented in an order which begins with abstract conceptualization (Reigeluth, 2013). In order to be effective, preservice teachers should learn the best method for taking existing curriculum materials and modifying the sequence, so that concrete experiences could be presented first.

Professional development should be created and presented to in-service teachers to highlight the effects of cognitive sequencing based on learning style. In-service should include instruction on how to present new concepts using both apprehension and comprehension beginning point. This will ensure that teachers are prepared to meet the individual needs of their students. Combining the knowledge of how to cognitively sequence instruction with an assessment of students in agricultural education courses could give teachers a prescriptive method for increasing student learning of STEM content.

The results of this study lead to additional areas for research related to the concepts of cognitive sequencing, learning disabilities, STEM education, and experiential learning theory in agricultural education. We recommend replication of this study in a population large enough to analyze data through inferential statistics in order to examine potential interactions between the factors of cognitive sequence and learning disabilities. The differences in student learning should be examined using cognitive sequencing of the transformation dimension of ELT to determine if differences exist when the transformation of knowledge begins through intention or extension for LD students.

The main goal of this research was not to build upon theory or substantiate the research of academics, though it would certainly be wonderful if these implications existed. The main goal of this research was to help those who spend every day working in the classroom. The importance of cognitive sequencing for in relation to STEM concepts, learning disabilities, and experiential learning theory has been highlighted by this initial examination, and revealed the importance of sequencing instruction. A continuation of this line of inquiry may yield results that can help level the playing field for all students, especially those for whom the playing field is vastly tilted.

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