

Utilizing Natural Cognitive Tendencies to Enhance Agricultural Education Programs

Alexa J. Lamm, Post Doctorate Associate

University of Florida

Emily B. Rhoades, Assistant Professor

The Ohio State University

Tracy A. Irani, Professor

T. Grady Roberts, Associate Professor

University of Florida

Lori J. Unruh Snyder, Assistant Professor

Purdue University

Joel Brendemuhl, Professor

University of Florida

The influences of cognitive styles have been the focus of research on problems in education for quite some time (Witkin, Moore, Goodenough, & Cox, 1977). In fact, agricultural educators are rapidly increasing the amount of research and education focused on understanding and utilizing cognitive function in an attempt to improve educational programs. The purpose of this study was to describe the relationships between three measures of cognitive function: critical thinking disposition, problem solving style, and learning style when participants are encouraged to engage in their natural cognitive tendencies by being placed in an intense environment. These three cognitive styles/dispositions were measured and analyzed for correlations. Substantial relationships were discovered. Cognitive abilities and preferences are repeatedly taken in to account when creating and revising educational programs to enhance student learning. With a greater understanding of how cognitive dispositions relate to one another, a clearer vision of student preferences and abilities can be taken in to account when creating educational curricula and activities.

Keywords: undergraduate students; cognition; problem solving; learning style; critical thinking

Introduction

Research on problems in education has been focusing on the influences of cognitive styles in formal and non-formal education settings for quite some time (Witkin, et al., 1977). Keefe (1979) defined cognitive styles as a learner's preferred way of organizing and retaining information. Critical thinking ability has been recurrently identified as a cognitive style necessary for students in the 21st century and crucial for individuals to be able to deal with decisions faced every day (Myers & Dyer, 2006; Torres & Cano, 1995). Along with critical thinking, problem solving style and learning

style are the primary cognitive styles being examined within agricultural education. In fact, agricultural educators are rapidly increasing the amount of research and education focused on understanding and utilizing cognitive function in an attempt to improve their programs (Boone, 1990; Cano, 1993; Dyer & Osborne, 1996a; Parr & Edwards, 2004).

Critical thinking ability is essential to student success; however, ability constantly changes as students learn and grow and is therefore extremely difficult to measure. By using critical thinking dispositions, which Irani et al. (2007) have identified as "the gateway through which one allows the mind to engage in

critical thinking activity,” (p. 2) a deeper, slowly changing preference rather than ability becomes the unit of measurement. These dispositions are measurements agricultural educators can use when assessing students and creating educational curriculum.

Critical thinking disposition, problem solving style, and learning styles have all been examined individually by agricultural educators with the results focused on how they can be used to enhance student learning (Boone, 1990; Cano, 1993, 1999; Cano & Martinez, 1991; Dyer & Osborne, 1996a, 1996b; Garton, Spain, Lamberson, & Spiers, 1999; Parr & Edwards, 2004; Rudd, Baker, & Hoover, 1998; Torres & Cano, 1994). In addition, cognitive relationships between critical thinking disposition and problem solving style, and critical thinking disposition and learning style, have been studied (Friedel, Irani, Rhoades, Fuhrman, & Gallo, 2008; Myers & Dyer, 2006; Rudd, Baker, & Hoover, 2000; Torres & Cano, 1995). However, all three have not been examined within the same context to gain an understanding of how they relate to one another. Since assessing the effectiveness of educational programs in agricultural and life sciences and improving the success of students enrolled in agricultural and life sciences academic and technical programs is part of the National Research Agenda: Agricultural Education and Communication, 2007–2010 (Osborne, 2007), a study exploring the ways in which natural cognitive function correlate and can be used to enhance student learning through enhanced agricultural education programs can yield valuable data providing direction for future practice.

Theoretical Framework

The conceptual framework for this study was created using theories that provide the foundation for the three cognitive styles being examined.

Critical Thinking Disposition

Critical thinking is a concept that has been challenging to define as exhibited by the many definitions available. Sumner (1940) defined critical thinking as “the intellectual processes by which the sense, sequence, interdependence, and rational consequences of facts are ascertained” (p. 32). A more current definition as stated by

Rudd et al. (2000) is “a reasoned, purposive, and introspective approach to solving problems or addressing questions with incomplete evidence and information, and for which an incontrovertible solution is unlikely” (p. 5). No matter the definition, critical thinking has been recognized as one of the most important cognitive traits leading to an individual’s success for quite some time (Sumner, 1940; Rudd et al., 2000; Irani, et al., 2007).

Facione (1990) was the first to attempt to describe dispositions as they pertain to critical thinking by conducting a Delphi study using top researchers in the field. Seven separate dispositions were identified (Facione, 1990). While conducting a factor analysis of the California critical thinking disposition inventory, Moore, Rudd, and Penfield (2002) found the dispositions identified by Facione in 1990 were not represented. In an attempt to more accurately measure critical thinking disposition, Irani et al. (2007) used the Delphi study results and a review of literature in the field of critical thinking to create a new instrument, the UF-EMI.

The UF-EMI (Irani et al., 2007) uses three constructs rather than seven: engagement, cognitive maturity, and innovativeness. A high engagement score signifies an ability to anticipate situations, look for opportunities to use reasoning skills, and confidence in reasoning, decision making and problem solving abilities (Irani et al., 2007). A high cognitive maturity score signifies a knowledge of predisposition prior to making decisions, recognition of the environment’s effect on opinions and an openness to the ideas of others. A high innovativeness score signifies a tendency to look for new knowledge, engage in new challenges, seek more knowledge, and an ability to question present beliefs, adjusting them based on new knowledge or experience.

Problem Solving Style

Kirton (2003) defined problem solving as an ability to “solve critical, complex problems in challenging environments” (p. 1). Since the world is ever-changing, problem solving becomes an essential part of human survival and is innate within each individual (Kirton, 2003). However, individuals approach problem solving differently. Adaption-Innovation theory (Kirton, 2003) asserted an individual’s style can be

identified on a continuum between levels of adaption and innovation. An adaptive individual narrowly focuses their attention to solving a problem within defined boundaries. An innovative individual approaches problems from a larger perspective, stepping outside of boundaries or defying rules to come up with multiple solutions to the same problem. In order to analyze adaptive versus innovative style, the KAI was created using three constructs: sufficiency of originality (a preference for forming solutions), efficiency (a preference to use strategy), and rule/group conformity (a preference for structure).

Learning Style

The experiential learning theory of development defines learning style as an individual's preferred method of gaining knowledge. In Kolb's (1984) learning style model, learners are divided into four categories: accommodating, assimilating, converging, and diverging. These four styles were created by evaluating the level at which the learner naturally tends to use reflective observation (reflecting), abstract conceptualization (thinking), active experimentation (doing), and concrete experience (experiencing) while learning (Kolb, 2007). A higher score in each of these areas signifies a preference for that style of learning.

Kolb (2007) identified typical characteristics associated with each of the four groups. Those preferring doing and experiencing are considered accommodators. They put practiced ideas into action, finding multiple uses for information learned, and are easily adaptive. Those who prefer reflection and thinking are considered assimilators. They see learning experiences as a gateway to larger ideas combining learned information to create models and theories. Those who prefer doing and thinking are considered convergers. They collect information to solve problems, bringing pieces together to reach a solution. Those preferring experiencing and reflecting are considered divergers. These individuals look at situations from multiple perspectives coming up with alternative solutions by diverging from traditional patterns.

Critical Thinking Disposition, Problem Solving Style, & Learning Style

Past research has shown critical thinking disposition and problem solving style may be linked through creative thinking. Studies have identified creative thinking as an essential part of critical thinking (Maltzman, 1960; Newell, Shaw, & Simon, 1962; Russell, 1956; Torrance & Torrance, 1973; Vinacke, 1952). At the same time, there is some debate as to whether creative thinking and problem solving are significantly different concepts. Kirton (2003) argued that problem solving style does not differentiate whether an individual is creative or not, but rather the differences in the way they express their creativity. Therefore, if creativity is not the link between problem solving and critical thinking, how are they related? Friedel et al. (2008) found low levels of correlation between critical thinking and problem solving, but concluded the two are probably more independent than previously thought.

Relationships between critical thinking disposition and learning style have also been examined within the field of agricultural education. While studying this relationship in undergraduate students, Rudd et al. (2000) reported no significant correlation between learning style and critical thinking disposition. Torres and Cano (1995) also expressed the need for further study when they discovered learning style only accounted for 9% of the variance in critical thinking ability.

Relationships between problem solving style and learning style were found in the management training context (Kirton, 2000). In these studies, reflection was associated with adaptors while action was associated with innovators. If this serves to be true, adaptors will prefer linear learning modes, and innovators will prefer hands on, experiential learning techniques (Kirton, 2000). A higher score within each of the three KAI constructs, sufficiency of originality, efficiency, and rule/group conformity, signifies an innovative preference, while a low score signifies an adaptive preference towards problem solving.

Purpose and Objectives

The purpose of this study was to describe the relationships between participant's critical

thinking disposition, problem solving style, and learning style. The research objectives were to:

1. Describe the participants' critical thinking disposition, problem solving style, and learning style.
2. Describe the relationships between the participants' critical thinking disposition, problem solving style, and learning style.
3. Create a conceptual model describing the relationships existing between critical thinking disposition, problem solving style, and learning style.

Methods

The study presented here was descriptive and correlational in nature. The population used for this study was made up of participants in two study abroad courses conducted during the summer and fall 2009 terms. Both were designed to remove the participants from their comfort zone. When individuals find themselves engaged in unfamiliar activities, coping behavior is activated, creating an environment that relies on preferred cognitive style to develop the needed behavior (Kirton, 2000). In addition, experiential learning was the teaching methodology used, with learning activities designed to stimulate participants possessing a variety of learning styles. The courses included cultural immersion techniques and problem solving activities. Together, these influences created an atmosphere designed to enhance the use of all three cognitive areas studied. With only 15 participants in one course and 13 in the other, a census of the 28 college age students involved was conducted. Due to the small size of the population, the results cannot be extrapolated beyond the limits of the environments described within this study.

Participants met with one of the researchers at the conclusion of both courses where they were asked to complete three assessments. These included the University of Florida Engagement, Maturity, and Innovativeness test (UF-EMI; Moore et al., 2002) to measure critical thinking disposition, Kirton's Adaption-Innovation Inventory (KAI; Kirton, 1976) to determine their problem solving style, and the Kolb Learning Style Inventory (LSI; Kolb, 2007) to determine learning style. Demographic data was also collected for descriptive purposes.

Instrumentation

To assess critical thinking disposition, the UF-EMI was used. This instrument was made up of 26 Likert-type items measuring the three constructs of critical thinking: engagement, cognitive maturity, and innovativeness (Irani et al., 2007). The total score on the instrument ranges from 26, indicating a low critical thinking disposition, to 130, indicating a high critical thinking disposition. Total reliability for the UF-EMI, as reported by the developers, was a Cronbach's alpha coefficient of .94 (Irani et al., 2007). Cronbach's alpha coefficients for the three constructs within the instrument are: engagement, .91; cognitive maturity, .79; and innovativeness, .80.

The KAI was used to assess problem solving style. The KAI was a 32-item instrument. Responses were totaled to create an overall score ranging from 32 to 160 (Kirton, 2003). Individuals scoring below 95 points were considered adaptors and those scoring above 95 were considered innovators. The KAI was also made up of three constructs: sufficiency of originality (a preference for forming solutions), efficiency (a preference to use strategy), and rule/group conformity (a preference for structure). Multiple research studies have established a high level of reliability and validity for this instrument (Kirton, 2003). In addition, numerous researchers have replicated high levels of reliability for the KAI, reporting Cronbach's alpha coefficients ranging from .80 to .90 (Taylor, 1989).

Learning style was determined by using the LSI. This 12-item instrument is used to determine learning style preferences within four categories: concrete experience (CE), active experimentation (AE), reflective observation (RO), and abstract categorization (AC). Each category had a score ranging from 12 to 48, with all four categories totaling 120. Categories with higher scores signified preference for this method of learning. Multiple research studies across disciplines have established a coefficient alpha level of reliability for the LSI ranging from .73 to .86 (Ruble & Stout, 1990).

Data Analysis

Descriptive statistics were used to calculate the first objective. Responses for all three inventories were coded for computer analysis using SPSS. Relationships between the

participant's critical thinking disposition, problem solving style, and learning style were described by calculating Pearson's product-moment correlation coefficient using Davis' (1971) convention. Magnitude of the relationship is noted by Davis as $.01 \geq R \leq .09$ = Negligible, $.10 \geq R \leq .29$ = Low, $.30 \geq R \leq .49$ = Moderate, $.50 \geq R \leq .69$ = Substantial, $R \geq .70$ = Very Strong. Proportion of the variation accounted for by the relationship is noted by R^2 .

Results

Demographics

The 28 participants recruited to take part in this project represented the University of Florida, Texas A&M, North Carolina State University, Purdue University, and The Ohio State University. Twenty-one of the participants were female and seven were male, ranging in age from 18 to 27 years of age. Twenty-four participants were undergraduate students (86%) and four were graduate students (14%). Twenty-six of the participants were White (non-Hispanic), one was Hispanic, and one was Caribbean.

Critical Thinking Disposition

The UF-EMI inventory was used to identify the participants' critical thinking disposition. The total score on the instrument ranges from 26, indicating a low critical thinking disposition, to 130, indicating a high critical thinking disposition. Participant scores reflected a range of critical thinking disposition scores, ranging from 43 to 119. Twelve had a score over 100 on the inventory, signifying a higher critical thinking disposition while sixteen scored a 100 or below, signifying a lower critical thinking disposition.

Problem Solving Style

The KAI inventory was administered to measure problem solving style. Using this instrument, scores within each category are summed to create a total score ranging from 32 to 160 (Kirton, 2003). Individuals scoring below 95 points are considered adaptors and those scoring above 95 are considered innovators. In this study participant scores ranged from 76 to 127. Seventeen participants were identified as innovators and eleven as adaptors.

Learning Style

The LSI was used to measure the participants' preferred learning style. Numerical measures are taken in each of the four categories: abstract categorization, active experimentation, concrete experience, and reflective observation. Reflective observation scores are subtracted from the active experimentation score to get an overall score representing how the person does things while learning. In addition, the concrete experience scores are subtracted from the abstract categorization scores to get an overall score representing how the person thinks about things while learning. These two scores are then mapped out on a grid to attain the individual's preferred learning style based on how the two scores interact (Kolb, 2007). The participants in this study represented each of the four categories. Seven were identified as accommodating, eight as assimilating, five as converging, and eight as diverging.

Relationships between Critical Thinking Disposition and Problem Solving Style

There were moderate correlations between participants' critical thinking disposition and their problem solving style (see Table 1). The overall UF-EMI score had a moderate correlation ($R = .36$) with the overall KAI score accounting for over a tenth of the effect ($R^2 = .13$). The cognitive maturity construct within the UF-EMI also had a moderate correlation ($R = .47$, $R^2 = .22$) with the overall KAI score, a substantial correlation with the rule/group conformity construct within KAI ($R = .54$, $R^2 = .29$), and a moderate correlation with the efficiency construct within KAI ($R = .42$, $R^2 = .18$). The innovativeness construct within the UF-EMI also had a moderate correlation ($R = .30$, $R^2 = .09$) with the overall KAI score, a moderate correlation with the efficiency construct within KAI ($R = .47$, $R^2 = .22$), and a moderate correlation with the rule/group conformity construct within KAI ($R = .41$, $R^2 = .17$). The engagement construct within the UF-EMI also had a moderate correlation with the rule/group conformity construct within KAI ($R = .39$, $R^2 = .15$). Two of the constructs within the KAI were moderately correlated to the overall UF-EMI score. The rule group conformity construct had a moderate correlation ($R = .47$, R^2

= .22) and the efficiency construct had a moderate correlation ($R = .33$, $R^2 = .11$).

Table 1

Correlations between Critical Thinking Disposition and Problem Solving Style

	Overall KAI	SO	E	R
Overall UF-EMI	.36	.08	.33	.47
Cognitive Maturity	.47	.19	.42	.54
Innovativeness	.30	.04	.47	.41
Engagement	.27	.01	.27	.39

Note. SO=Sufficiency of Originality, E=Efficiency, R=Rule/Group Conformity

Relationships between Critical Thinking Disposition and Learning Style

When LSI preferences are viewed in comparison to total scores on the UF-EMI, those exhibiting an accommodating learning style tended to have a lower critical thinking

disposition score (see Table 2). In addition, those with a converging learning style preference exhibited a higher critical thinking disposition score. Those exhibiting either an assimilating or diverging learning style had a range of total critical thinking disposition scores.

Table 2

Learning Style Preference Comparisons with Critical Thinking Scores and Problem Solving

Participant #	Inventory Preference	Total EMI Score	Total KAI Score
20	Accommodating	100	85
18	Accommodating	100	78
13	Accommodating	94	110
26	Accommodating	94	82
15	Accommodating	92	106
9	Accommodating	93	83
27	Accommodating	89	98
1	Assimilating	113	118
3	Assimilating	109	123
17	Assimilating	104	108
6	Assimilating	103	108
2	Assimilating	100	92
19	Assimilating	92	89
16	Assimilating	92	84
23	Assimilating	64	106
28	Converging	119	121
11	Converging	107	111
10	Converging	104	125
12	Converging	104	107
7	Converging	104	85
24	Diverging	106	127
5	Diverging	105	120
22	Diverging	102	102
14	Diverging	100	94
4	Diverging	98	101
8	Diverging	92	76
25	Diverging	90	105
21	Diverging	43	93

Only one of the constructs within the LSI had moderate correlations to the UF-EMI (see Table 3). The active experimentation construct moderately correlated to the overall UF-EMI score ($R = -.38$, $R^2 = .14$) accounting for almost 15% of the variation. This construct also

moderately correlated with the engagement construct ($R = -.42$, $R^2 = .18$), the cognitive maturity construct ($R = -.32$, $R^2 = .10$), and the innovativeness construct ($R = -.32$, $R^2 = .10$) within the UF-EMI.

Table 3

Correlations between Critical Thinking Disposition and Learning Style

	AC	AE	RO	CE
Overall UF-EMI	.02	-.38	.03	-.08
Engagement	.12	-.42	.11	-.11
Cognitive Maturity	-.09	-.32	.00	-.01
Innovativeness	-.03	-.32	-.07	-.12

Note. AC = Abstract Categorization, AE = Active Experimentation, RO = Reflective Observation, CE = Concrete Experience.

Relationships between Problem Solving Style and Learning Style

When learning style inventory preferences were viewed in comparison to total scores on the KAI, there are no obvious relationships (see Table 2). The total KAI scores varied within

each learning style preference. Strong correlations between the participant's problem solving style and the constructs within the learning style inventory were not found (See Table 4).

Table 4

Correlations between Problem Solving Style and Learning Style

	Overall KAI	SO	E	R
Active Experimentation	-.15	-.01	-.17	-.21
Abstract Categorization	.10	.10	.01	.11
Reflective Observation	-.25	-.29	-.10	-.21
Concrete Experience	.29	.23	.29	.22

Note. SO=Sufficiency of Originality, E=Efficiency, R=Rule/Group Conformity

Using the theoretical framework of the cognitive styles identified: critical thinking disposition, problem solving style, and learning style along with the results from this study, a conceptual model representing the relationships between the three styles was developed (see Figure 1). While it may be premature to develop a model based on such a small population, the development process connected the correlations in a visual way. This process also created a unique vision of how cognitive styles relate that can be further tested.

The results show problem solving style is correlated with critical thinking disposition. The

conceptual model shows those with higher critical thinking disposition scores will most likely be innovators while those with a lower critical thinking disposition score will most likely be adaptors. Individuals with a higher critical thinking disposition were also correlated to those exhibiting a converger preference when learning while those with a lower critical thinking disposition were correlated with those exhibiting accommodator preferences while learning. The conceptual model reflects this relationship as well. Problem solving style and learning style were not found to be correlated therefore they are only shown to be connected

through critical thinking disposition. This study shows how connections between multiple aspects of cognitive style remain hidden until applied to the same group, at the same time, and

gives further insight in to the relationships between critical thinking disposition, problem solving style, and learning style.

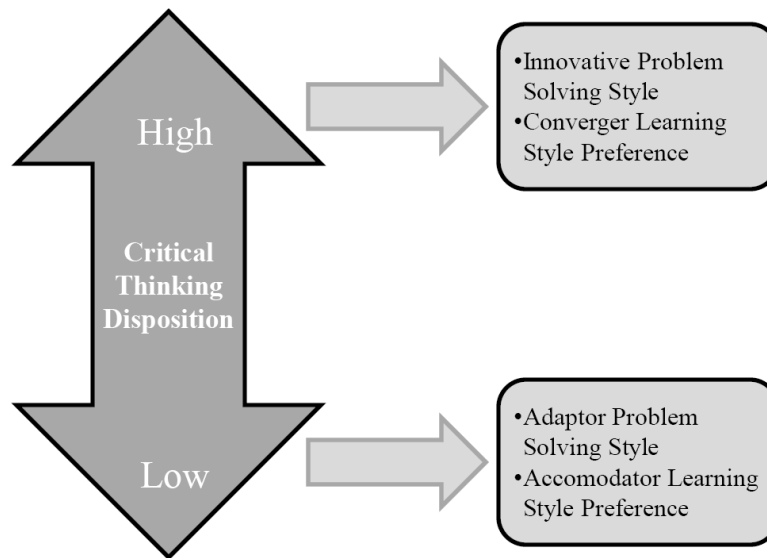


Figure 1. A conceptual model of the relationships between critical thinking disposition, learning style, and problem solving style based on the study.

Conclusions

This study sheds light on how critical thinking disposition, problem solving style, and learning style relate to one another. The main limitation of the study was the use of a census. As such, the results reported were population parameters and cannot be extrapolated beyond the limits of the environment described within the study.

Based on previous research, adaptors would have exhibited a preference for linear learning modes, while innovators should have preferred hands on, experiential learning techniques (Kirton, 2003). While the literature suggested a relationship existed between problem solving style and learning style, the results from the group of students in this study showed a relationship between problem solving style and learning style did not exist.

A relationship did exist between problem solving style and critical thinking disposition in

this study. Having only found low levels of correlation between critical thinking and problem solving, Friedel et al. (2008) concluded the two were more independent than originally thought. However, when separate constructs were included in this comparison, it revealed those holding an innovative preference for forming solutions and dealing with structure while problem solving tended to have a higher critical thinking disposition. This is especially true as it relates to the individual's ability to acknowledge their own predisposition when thinking critically and their ability to recognize how their environment can have an effect on the way they think.

The most unexpected result of the study was the identification of a relationship between critical thinking disposition and learning style. In previous studies, Rudd et al. (2000) found no significant correlations between learning style and critical thinking disposition and Torres and Cano (1995) discovered learning style only

accounted for a very small portion of the variance in critical thinking. While the overall critical thinking disposition and overall learning style were not strongly correlated within this study, connections between the active experimentation construct and critical thinking score existed. Those individuals with a strong preference for abstract categorization (thinking) and active experimentation (doing) when learning had a very strong relationship to those who anticipate situations, look for opportunities, and are confident in their abilities when thinking critically.

Implications & Recommendations

The key implication for agricultural educators working to enhance educational programs is to be aware of, and address, the connections between different cognitive dispositions and styles. Critical thinking ability has been recurrently identified as a cognitive style necessary for students to be successful in today's workplace (Myers & Dyer, 2006). This study shows there are connections between innovative problem solvers and a high critical thinking disposition. It also shows those with a strong preference for abstract categorization (thinking) and active experimentation (doing) when learning had a very strong relationship with several critical thinking items. While students exhibiting these characteristics are naturally setting themselves up for success

outside of school, educators need to be aware of, and pay attention to the need to stress critical thinking with students who do not exhibit these tendencies. If critical thinking is demanded by employers, educators need to consider implementing strategies that focus on building student capacity in this area such as integrating more ill-defined problems in their courses.

Cognitive abilities and preferences are repeatedly taken in to account when creating and revising educational programs to enhance student learning. This study shows innovative problem solvers are highly engaged when asked to critically assess a situation. In addition, these individuals will react to learning strategies targeted at doing and thinking, fitting in with the converging learning style. With a greater understanding of how cognitive dispositions relate to one another, a clearer vision of student preferences and abilities can be taken in to account when creating classroom activities.

Additional research measuring future participant's cognitive abilities in similar study abroad courses would assist in determining if the results found here are localized to this population. In addition, research examining whether or not the context of the courses had an effect on these relationships could be useful. A similar study conducted with individuals of similar demographic make-up involved in typical, everyday activities would be a way to examine whether or not the influence of the international environment had an effect.

References

- Boone, H. N. (1990). Effect of level of problem solving approach to teaching on student achievement and retention. *Journal of Agricultural Education*, 31(1), 18–26. doi: [10.5032/jae.1990.01018](https://doi.org/10.5032/jae.1990.01018)
- Cano, J. (1993). An assessment of the level of cognitive performance and critical thinking ability of selected agricultural education students. *Journal of Agricultural Education*, 34(2), 25–30. doi: [10.5032/jae.1993.02025](https://doi.org/10.5032/jae.1993.02025)
- Cano, J. (1999). The relationship between learning style, academic major, and academic performance of college students. *Journal of Agricultural Education*, 40(1), 30–37. doi: [10.5032/jae.1999.01030](https://doi.org/10.5032/jae.1999.01030)
- Cano, J., & Martinez, C. (1991). The relationship between cognitive performance and critical thinking abilities among selected agricultural education students. *Journal of Agricultural Education*, 32(1), 24–29. doi: [10.5032/jae.1991.01024](https://doi.org/10.5032/jae.1991.01024)
- Davis, J. A. (1971). *Elementary survey analysis*. Englewood Cliffs, NJ: Prentice–Hall.

- Dyer, J. E., & Osborne, E. W. (1996a). Effects of teaching approach on achievement of agricultural education students with varying learning styles. *Journal of Agricultural Education*, 37(3), 43–51. doi: [10.5032/jae.1996.03043](https://doi.org/10.5032/jae.1996.03043)
- Dyer, J. E., & Osborne, E. W. (1996b). Effects of teaching approach on problem solving ability of agricultural education students with varying learning styles. *Journal of Agricultural Education*, 37(4), 38–45. doi: [10.5032/jae.1996.04038](https://doi.org/10.5032/jae.1996.04038)
- Facione, P. (1990). *Critical thinking: A statement of expert consensus for purposes of educational assessment and instruction*. Millbrae, CA: The California Academic Press.
- Friedel, C. R., Irani, T. A., Rhoades, E. B., Fuhrman, N. E., & Gallo, M. (2008). It's in the genes: Exploring relationships between critical thinking and problem solving in undergraduate agriscience students' solutions to problems in mendelian genetics. *Journal of Agricultural Education*, 49(4), 25–37. doi: [10.5032/jae.2008.04025](https://doi.org/10.5032/jae.2008.04025)
- Garton, B. L., Spain, J. M., Lamberson, W. R., & Spiers, D. E. (1999). Learning styles, teaching performance and student achievement: A relational study. *Journal of Agricultural Education*, 40(3), 11–20. doi: [10.5032/jae.1999.03011](https://doi.org/10.5032/jae.1999.03011)
- Irani, T., Rudd, R., Gallo, M., Ricketts, J., Friedel, C., & Rhoades, E. (2007). *Critical thinking instrumentation manual*. Retrieved from http://step.ufl.edu/resources/critical_thinking/ctmanual.pdf
- Keefe, J. W. (1979). Learning style: An overview. In NASSP's student learning styles, *Diagnosing and prescribing programs* (pp. 1–17). Reston, VA: National Association of Secondary School Principals.
- Kirton, M. J. (1976). Adaptors and innovators: A description of measure. *Journal of Applied Psychology*, 61, 622–629.
- Kirton, M. J. (2000). *Adaptors and innovators: Styles of creativity and problem solving*. Rickmansworth, Hertfordshire, UK: KAI Distribution Centre.
- Kirton, M. J. (2003). *Adaption–innovation: In the context of diversity and change*. New York, NY: Routledge.
- Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development*. Englewood Cliffs, NJ: Prentice–Hall, Inc.
- Kolb, D. A. (2007). *Kolb learning style inventory*. Experience Based Learning Systems, Inc.
- Maltzman, I. (1960). On the training of originality. *Psychological Review*, 38, 332–346.
- Moore, L., Rudd, R., & Penfield, R. (2002). *A factor analysis of the California critical thinking disposition inventory*. Unpublished manuscript, Department of Agricultural Education and Communications, University of Florida, Gainesville, FL.
- Myers, B. E., & Dyer, J. E. (2006). The influence of student learning style on critical thinking skill. *Journal of Agricultural Education*, 47(1), 43–52. doi: [10.5032/jae.2006.01043](https://doi.org/10.5032/jae.2006.01043)
- Newell, A., Shaw, J. C., & Simon, H. A. (1962). *The process of creative thinking*. New York, NY: Atherton.

- Osborne, E. W. (Ed.) (2007). *National research agenda: Agricultural education and communication, 2007–2010*. Gainesville, FL: University of Florida, Department of Agricultural Education and Communication.
- Parr, B., & Edwards, M. C. (2004). Inquiry-based instruction in secondary agricultural education: Problem solving – an old friend revisited. *Journal of Agricultural Education*, 45(4), 106–113. doi: [10.5032/jae.2004.04106](https://doi.org/10.5032/jae.2004.04106)
- Ruble, T. L., & Stout, D. E. (1990). A psychometric analysis of Kolb's revised learning style-inventory. *Developments in Business Simulation & Experiential Exercises*, 17, 147–149.
- Rudd, R. D., Baker, M., & Hoover, T. (1998). Student and faculty learning styles within academic units in the University of Florida's College of Agriculture. *NACTA Journal*, 42(3), 18–24.
- Rudd, R. D., Baker, M., & Hoover, T. (2000). Undergraduate agriculture student learning styles and critical thinking abilities: Is there a relationship? *Journal of Agricultural Education*, 41(3), 2–12. doi: [10.5032/jae.2000.03002](https://doi.org/10.5032/jae.2000.03002)
- Russel, D. (1956). *Children's thinking*. New York, NY: Ginn & Co.
- Sumner, W. G. (1940). *Folkways: A study of the sociological importance of usages, manners, customs, mores, and morals*. New York, NY: Ginn & Co.
- Taylor, W. G. K. (1989). The Kirton adaption-innovation inventory: A re-examination of the factor structure. *Journal of Organizational Behavior*, 10(4), 297–307.
- Torres, R. M., & Cano, J. (1994). Learning styles of students in a College of Agriculture. *Journal of Agricultural Education*, 35(4), 61–66. doi: [10.5032/jae.1994.04061](https://doi.org/10.5032/jae.1994.04061)
- Torres, R. M., & Cano, J. (1995). Critical thinking as influenced by learning style. *Journal of Agricultural Education*, 36(4), 55–62. doi: [10.5032/jae.1995.04055](https://doi.org/10.5032/jae.1995.04055)
- Torrance, E. P., & Torrance, P. (1973). *Is creativity teachable?* Bloomington, IN: Phi Delta Kappa.
- Vinacke, W. E. (1952). *The psychology of thinking*. New York, NY: McGraw-Hill.
- Witkin, H. A., Moore, C. A., Goodenough, D. R., & Cox, P. W. (1977). Field-dependent and field-independent cognitive styles and their educational implications. *Review of Educational Research*, 47(1), 1–64.

ALEXA J. LAMM is a Post Doctorate Associate in the Department of Agricultural Education and Communication at the University of Florida, 310 Rolfs Hall, Gainesville, FL 32611, alamm@ufl.edu.

EMILY B. RHOADES is an Assistant Professor of Human and Community Resource Development at the Ohio State University, 208 Agricultural Administration Building, Columbus, OH 43210, rhoades.100@osu.edu.

TRACY A. IRANI is a Professor of Agricultural Communication in the Department of Agricultural Education and Communication at the University of Florida, 206 Rolfs Hall, Gainesville, FL 32611, irani@ufl.edu.

T. GRADY ROBERTS is an Associate Professor of Agricultural Education in the Department of Agricultural Education and Communication at the University of Florida, 305B Rolfs Hall, Gainesville, FL 32611, groberts@ufl.edu.

LORI J. UNRUH SNYDER is an Assistant Professor of Agronomy in the Department of Agronomy at Purdue University, Lilly 2-41 4E, West Lafayette, IN 47907, ljsnyder@purdue.edu.

JOEL BRENDemuHL is a Professor of Animal Science in the Department of Animal Science at the University of Florida, 100C Bldg. 459, Gainesville, FL 32611, brendj@ufl.edu