

A Critical Thinking Benchmark for a Department of Agricultural Education and Studies

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Abstract

Due to an ever changing world where technology seemingly provides endless answers, today's higher education students must master a new skill set reflecting an emphasis on critical thinking, problem solving, and communications. The purpose of this study was to establish a departmental benchmark for critical thinking abilities of students majoring in agricultural education and studies. Seventy-five senior-level undergraduates completed a Critical Thinking Assessment Test (CAT) during the spring 2013 semester. A one-sample t-test utilizing national norm data and a step-wise regression model analyzing predictors of critical thinking ability were used to address research objectives. The only critical thinking skill area where participants' mean scores were statistically higher than the national norm mean score was in the ability to summarize a pattern of results from a graph without making inappropriate inferences. Further, step-wise regression for total critical thinking score revealed ACT score was the only significant predictor of overall critical thinking ability.

Keywords: critical thinking; problem solving; communication; benchmark

Recent reforms in higher education reflect an emphasis on critical thinking, problem solving, and communications (Paul, 1995; Rhodes, Miller, & Edgar, 2012; Willson, 1995; Wright, 1992). Critical thinking ability has continually been identified by universities and employers as a desired outcome for college graduates (Association of American Colleges and Universities [AACU], 2004, 2007, 2010). Yet, limited research is available examining critical thinking abilities of students in colleges of agriculture (Rudd, Baker, & Hoover, 2000).

Although critical thinking is seen as an important outcome of higher education, “a single, widely-accepted, cross-disciplinary definition for critical thinking still does not exist” (Sanders & Moulenbelt, 2011, p. 38). Initial confusion surrounding critical thinking includes the misguided belief that students' abilities to explain concepts in their own words equate to critical thinking skills (Choy & Cheah, 2009). This perception of critical thinking is a false identification and instead, may represent the natural process students undergo in making sense of new information (Choy & Cheah, 2009).

Critical thinking is purposeful thinking where individuals systematically impose criteria and intellectual standards upon thought (Paul, 1995). Critical thinking involves an honest attempt to identify, dissect, and assess reasons, premises, and conclusions of competing arguments (Possin, 2008). It is important to note critical thinking is not simply a random compilation of components (Willson, 1995). Critical thinking should be viewed as an integrated working system that can be applied to academic environments as well as to everyday aspects of life (Willson, 1995).

Higher education institutions often face the challenge of examining and assessing students' critical thinking abilities. Wagner (2008) identified problem solving, accessing and analyzing

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information, effective oral and written communications, and curiosity and imagination among a set of skills students need to be successful in the changing higher education environment. These four skill areas align with the broad domains of the critical thinking assessment instrument utilized in this study, the Critical Thinking Assessment Test (CAT): (a) evaluate and interpret information, (b) problem solving, (c) effective communication, and (d) creative thinking.

The first domain assessed by the CAT, evaluating and interpreting information, has been consistently recognized as an integral component of critical thinking (Duron, Limbach, & Waugh, 2006; Facione, 2011; Possin, 2008; Wagner, 2008) and, therefore, should be assessed as such. Multiple critical thinking assessment instruments incorporate individuals' abilities to evaluate and interpret information. Research has shown college of agriculture students obtain slightly below (Friedel, Irani, Rhoades, Fuhrman, & Gallo, 2008) to slightly above (Friedel, Irani, Rudd et al., 2008) average total possible points in evaluation and interpretation measurements as they pertain to critical thinking abilities.

Effective oral and written communications are identified among a list of skills required for success in higher education (Wagner, 2008). As excellence in writing requires excellence in thinking, practicing written communication is one of the best ways to practice thinking (Willson, 1995). "Writing requires that one systemize one's thinking, arranging thought in a progression that makes the system of one's thought accessible to others" (Willson, 1995, p. 30). Due to the high frequency of usage of multiple-choice formatted critical thinking assessments, it is difficult to find empirical research detailing the relationship between effective oral and written communications and critical thinking.

Elevated critical thinking disposition levels can be attributed to a student's preference to solve problems (Friedel, Irani, Rhoades, et al., 2008). Central to problem solving ability is deductive reasoning (Facione, 2011; Schechter, 2013). The Cornell Critical Thinking Test (CCTT) explores individual's deductive reasoning skills as a partial construct to determine overall critical thinking ability (Ennis, Millman, & Tomko, 1985). Iwaoka, Li, and Rhee (2010) measured critical thinking abilities of undergraduate food science and human nutrition students with the CCTT and revealed significant increases in deduction skills over the period of one course, as well as significant increases in their overall critical thinking score. Brahmasrene and Whitten (2011) discovered an average deductive reasoning skill level of 49.0% when administering the California Critical Thinking Skills Test (CCTST) (Facione, 1992) to entry level undergraduate business majors.

The most effective applications of critical and creative thinking occur when the two processes are highly integrated (Bleedorn, 1993). Similar to intelligence and learning capacity, creativity can be learned (Saavedra & Opfer, 2012), but its development requires structure and intentionality from instructors and students alike (Robinson, 2001). Highly creative people tend to display ample open-mindedness (Arieti 1976), a construct assessed by the California Critical Thinking Disposition Inventory (CCTDI). Rudd et al. (2000) utilized the CCTDI to explore the critical thinking dispositions of upper level undergraduates in a college of agriculture. Results indicated participants did not possess strong overall critical thinking dispositions or tendencies to open-mindedness.

Critical thinking skills are developed as a result of critical thinking dispositions and a set of facilitating factors, which include experience, training, sex, grade point average (GPA), and age (Ricketts & Rudd, 2005). When researching broad teaching and learning components, sex is continually identified as a key factor (Bers, McGowen, & Rubin, 1996). However, little consistency surrounds the role of sex in critical thinking development. Some research suggested the rate of critical thinking development among males is higher than females (King, Wood, & Mines, 1990), while other research suggested females possess higher critical thinking abilities (Bers et al., 1996; Rudd et al., 2000). Yet, sex has also been shown to possess limited (Jacobs, 1995) to no significant influence on critical thinking ability (Brahmasrene & Whitten, 2011; Brisdorf-Rhoades, Ricketts, Irani, Lundy, & Telg, 2005; Burbach, Matkin, Quinn, & Searle, 2012; Friedel, Irani, Rhoades et al., 2008; Friedel, Irani, Rudd et al., 2008).

Slightly more clarity in predicting critical thinking ability is evident when age is considered a facilitating factor. Older students, typically over age 25, display statistically significant higher critical thinking dispositions than younger students (Bers et al., 1996). Although not as strong as the relationships found in other research (Bers et al., 1996), Jacobs (1995) claimed age as a second predictor of critical thinking skills behind SAT verbal scores. However, some research suggested no significant connections exist between students' ages and critical thinking dispositions (Burbach et al., 2012; Rudd et al., 2000).

Academic characteristics are more reliable than demographic characteristics to explain variations among critical thinking abilities. GPA and year in school are the most consistent predictors of students' critical thinking dispositions and abilities (Burbach et al., 2012; Friedel, Irani, Rhoades et al., 2008). A deeper understanding of the relationship between academic characteristics and critical thinking skills has been found through exploring SAT relationships. Highly significant *t*-values ($p < .01$) are evident when examining the effect of SAT verbal and mathematical scores on total critical thinking assessment scores (Brahmasrene & Whitten, 2011). More specifically, SAT verbal scores are the best predictors of critical thinking abilities when utilizing SAT scores (verbal and mathematical), age, and sex as predictor variables in regression analyses (Jacobs, 1995).

Research has yet come to a consensus regarding the influence demographic and academic characteristics have on critical thinking abilities of higher education students. Further, a need exists to evaluate the critical thinking abilities of senior-level agriculture students utilizing an assessment instrument that incorporates constructs reflective of the changing focus of higher education. How well developed are the critical thinking abilities of agricultural education students and what facilitating factors truly influence the development of these abilities?

Conceptual Framework

In an attempt to address the higher education issue of integrating specific learning activities into holistic pedagogical approaches that facilitate critical thinking, Duron et al. (2006) created the *5-Step Model to Move Students Toward Critical Thinking* (Figure 1). The 5-Step Model utilizes Bloom's (1956) taxonomy as a foundation to outline a cyclical process that assists higher education instructors in the intentional development, integration, and evaluation of critical thinking instruction. The model presumes critical thinking is present when students perform in the higher-ordered thinking levels of Bloom's (1956) taxonomy, such as the *Analysis*, *Synthesis*, and *Evaluation* levels (Duron et al., 2006). The model provided a platform for making recommendations to instructors regarding specific approaches that can assist in developing students' critical thinking abilities.

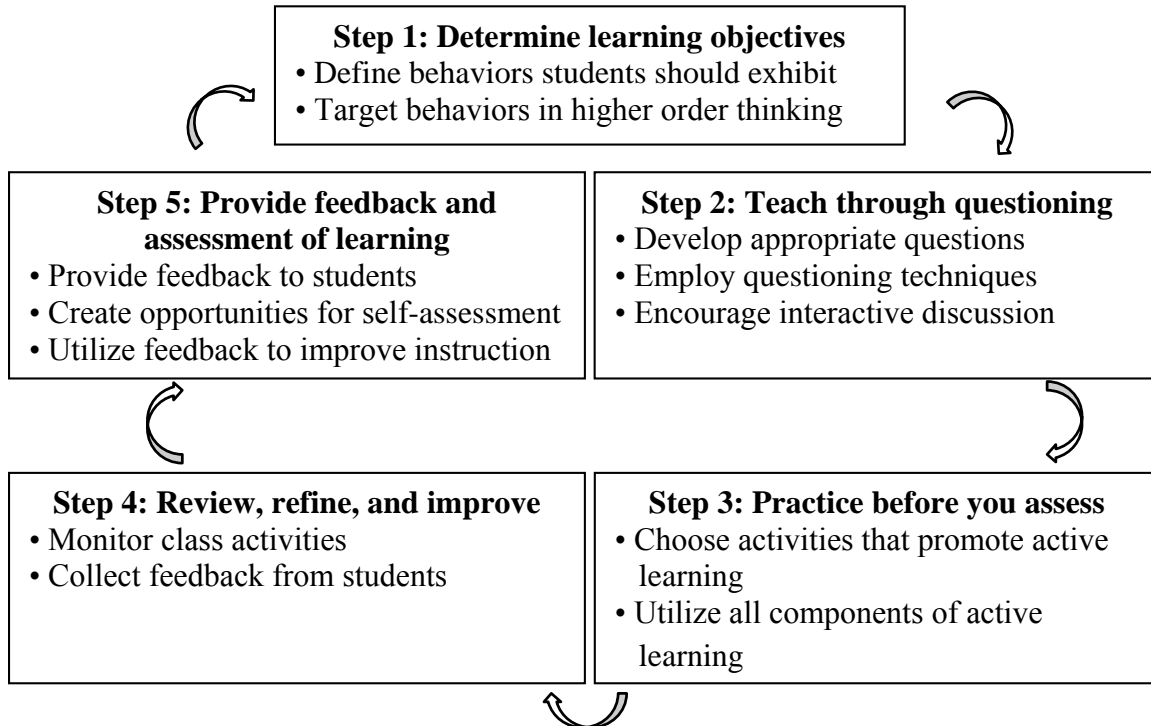


Figure 1. 5-Step model to move students toward critical thinking (Duron et al., 2006).

Step one is to create higher ordered learning objectives, activities, and assessments that define expected behaviors upon course completion (Duron et al., 2006). Step two focuses on teaching through divergent questioning, since it is an effective means of building critical thinking skills because it stimulates students to defend stances (Duron et al., 2006). Step three stresses the importance of instructor practice before assessment and selection of active learning activities, such as gathering information from a variety of sources, incorporating the newly attained information, and in-depth reflective dialog assignments (Fink, 2003). Step four is reviewing, refining, and improving courses to ensure critical thinking remains a focal point of instructional techniques (Duron et al., 2006) and collect vital student information required to adjust learning techniques (Angelo & Cross, 1993). The final step is to provide feedback and assessment of learning for the purpose of enhancing the quality of instruction, as well as student learning and performance (Duron et al., 2006).

Purpose and Objectives

As part of a larger investigation, the purpose of this study was to establish a departmental benchmark for critical thinking abilities of undergraduate agricultural education and studies students. The purpose of this study aligns with the American Association for Agricultural Education's National Research Agenda Research Priority Area 4: Meaningful, Engaged Learning in All Environments (Doerfert, 2011) by addressing the following research objectives:

1. Determine agricultural education and studies students' critical thinking scores in reference to national user norms.
2. Explore potential associations among selected student demographic and academic characteristics, and critical thinking abilities.

Methods and Procedures

Population and Sample

All senior-level undergraduates (90+ semester credit hours; $N = 181$) in the Department of Agricultural Education and Studies at Iowa State University (ISU) during the spring 2013 semester were identified as the target population. A computerized random number generator was utilized to compile a simple random sample from the alphabetized names on the ISU ten-day enrollment list to achieve a representative sample size of 124 students at a 95% confidence level as recommended by Dillman, Smyth, and Christian (2009). An analysis of the demographic and academic information of this sample population was conducted to enable comparisons among the students randomly sampled. This analysis revealed the typical student in the sample population to be a white (94.4%) male (66.8%) between the ages of 21 and 25 (93.3%), who was enrolled in an average of 14.39 semester credit hours, had completed an average of 112.29 total credit hours, and had achieved an average cumulative GPA of 2.77 on a 4.00 scale.

Instrument

Due to utilization of open-ended responses, as well as national reference norms, critical thinking abilities were assessed using the CAT. The CAT is a National Science Foundation supported tool created to assess and improve critical thinking and real-world problem solving skills (Center for Assessment and Improvement of Learning [CAIL], 2012). The CAT included 15 short answer questions based on real-world situations developed by university faculty across the nation to accurately assess 15 important components of critical thinking (CAIL, 2010). Under direct supervision of CAIL-trained individuals, the participating institution's faculty completed scoring of the CAT assessments for the present study. Detailed scoring rubrics provided by CAIL were utilized to enhance consistency and reliability in evaluations of the completed instruments.

Among other uses, the CAT instrument is designed to evaluate the effects of a collegiate program of study (CAIL, 2012). The 15 specific skill areas assessed by the CAT instrument (Figure 2) were developed and validated by an interdisciplinary team of faculty (CAIL, 2013), thus establishing face validity. The 15 specific skill areas were further grouped into four overlapping broad categories: (a) creative thinking, (b) problem solving, (c) evaluate and interpret information, and (d) effective communication.

CAIL (2010) reported inter-rater reliability examinations on the CAT at the level of .82. Gall, Gall, and Borg (1996) claim reliability coefficients of .80 or higher are "sufficiently reliable" (p. 200). Inter-rater reliability was further established by scoring each question with a minimum of two faculty scorers. If the initial two scorers were in disagreement, a different scorer evaluated the question a third time. Internal consistency was deemed reasonably good by CAIL (2010) at an alpha level of .70. CAIL (2010) explained the lower internal consistency was due, in part, to the numerous components of critical thinking evaluated by the instrument. Additionally, CAIL conducted an independent accuracy check on a subset of the test scored. The overall accuracy was well within the allowable margin of error ensuring the scores were valid for comparison to national norms.

Specific Skill Areas Assessed by the Critical Thinking Assessment Test	
<ul style="list-style-type: none"> • Summarize the pattern of results in a graph without making inappropriate inferences • Evaluate how strongly correlational-type data supports a hypothesis • Provide alternative explanations for a pattern of results • Identify additional information needed to evaluate a hypothesis • Evaluate whether spurious information strongly supports a hypothesis • Provide alternative explanations for spurious associations • Identify additional information needed to evaluate a hypothesis • Use/apply relevant information to evaluate a problem 	<ul style="list-style-type: none"> • Determine whether an invited inference in an advertisement is supported by specific information • Provide relevant alternative interpretations for a specific set of results • Separate relevant from irrelevant information when solving a real-world problem • Use basic mathematical skills to help solve a real-world problem • Identify suitable solutions for a real-world problem using relevant information • Identify and explain the best solution for a real-world problem using relevant information • Explain how changes in a problem situation might affect the solution

Figure 2. Skill areas assessed by the Critical Thinking Assessment Test (CAIL, 2012).

Procedure

A modified version of Dillman et al.’s (2009) Tailored Design Method was followed when requesting student participation. Five points of contact with participants yielded 75 completed tests, which accounted for 60.48% of the randomly selected senior- level students. Even after following suggested contact protocol, non-response error can still be problematic (Dillman et al., 2009). Handling non-response error has been recommended for studies achieving as high as 75% (Ary, Jacobs, & Razavieh, 1996), 80% (Gall et al., 1996; Tuckman, 1999), and even 90% (Linder, Murphy, & Briers, 2001) response rates. Non-response error was addressed by comparing respondents’ and non-respondents’ personal and demographic data to population data (Miller & Smith, 1983). A Pearson’s χ^2 analysis yielded no significant difference ($p > .05$) for sex and a two-sample t -test yielded no significance differences ($p > .05$) for age, cumulative GPA, and ACT score between respondents and non-respondents. However, caution should be used when extrapolating results beyond the population as respondents were representative of a homogenous sample regarding educational degree pursuit.

Measures of central tendency were used to describe the demographic and academic characteristics in objective one. University-specific terminology was used to describe participants’ academic characteristics. Semester credit hours included the number of credit hours in which the participant was enrolled during the semester of the study. Semester GPA reflected the previous semester’s GPA. Cumulative credit hours included the number of credit hours taken at the current university and cumulative GPA reflected the GPA of these credit hours. Total credit hours completed was defined as the sum of both credit hours taken at the current university and any credit hours that may have been transferred from another institution.

A one-sample t -test utilizing CAT national norm data collected from junior and senior-level higher education students across the nation ($n = 15,060$) and the present study ($n = 75$) was

conducted to address objective two (Gall et al., 1996). The third objective sought to determine if selected variables explained a significant proportion of the variance in students' critical thinking abilities. The dependent variable was critical thinking and problem solving abilities measured by the CAT instrument. Independent variables included sex, age, semester hours completed, semester GPA, cumulative hours, cumulative GPA, total hours, and ACT score. Variables were entered in PASW using a stepwise multiple regression to link predictor variables to criterion variables, where criterion variables were continuous, and predictor variables were both continuous and nominal (Gall et al., 1996). Effect sizes quantifying group differences were interpreted using Cohen's (1992) criteria, where 0.02 was considered small, 0.15 was medium, and 0.35 was large.

Results

Demographic and academic characteristics of participating agricultural education and studies students are displayed in Table 1. The sample was primarily comprised of males (66.7%) between the ages of 21 and 25 (94.7%). The entire sample (100.0%) self-identified themselves as white.

Table 1

Demographic Information of Agricultural Education and Studies Students (n=75)

	<i>f</i>	%
Sex		
Male	50	66.7
Female	25	33.3
Age		
20 years of age and under	2	2.7
21-25 years of age	71	94.7
Over 26 years of age	2	2.7
Race		
White	75	100.0

Table 2 reports participants' academic information. The typical participant was enrolled in an average of 14.46 (*SD* = 2.35) semester credit hours and had an average semester GPA of 2.95 (*SD* = 0.71) on a 4.00 scale. The average cumulative credit hours completed was 77.26 (*SD* = 28.97) and participants' cumulative GPA averaged 2.83 (*SD* = 0.56) on a 4.00 scale. Further, the average participant's ACT score was 21.48 (*SD* = 3.40).

Table 2

Academic Information of Agricultural Education and Studies Students (n=75)

	<i>M</i>	<i>SD</i>
Semester credit hours	14.46	2.35
Semester GPA	2.95	0.71
Cumulative credit hours	77.26	28.97
Cumulative GPA	2.83	0.56
Total credit hours	113.86	14.43
ACT Score	21.48	3.40

The first objective sought to report agricultural education and studies students' critical thinking scores in reference to national user norms. Table 3 displays *t*-test analyses of participants'

scores for each skill area of the CAT compared to the upper level CAT national norms. Table 3 also displays the specific skill areas assessed by the CAT as categorized by the four broad domains—evaluate and interpret information, problem solving, creative thinking, and effective communications. Each of these four domains is comprised of a portion of the 15 questions of the CAT instrument. Evaluate and interpret information had eight questions, problem solving included eight questions, creative thinking had six questions, and effective communication included nine questions. Participants scored statistically higher ($p < .05$) than national norms on one of the eight skill areas and statistically lower ($p < .05$) on one of the eight skill areas within the evaluate and interpret information domain. Participants scored statistically lower ($p < .05$) on three of the eight skill areas within the problem solving domain, on four of the six skill areas within the creative thinking domain, and on four of the nine skill areas within the problem solving domain.

Although resulting in a small effect size, the only skill area where participants' mean score ($M = 0.79$; $SD = 0.41$) was statistically higher ($p < .05$; $d = 0.29$) than the national norm mean score ($M = 0.67$; $SD = 0.46$) was the ability to summarize the pattern of results in a graph. Participants' scored significantly lower than national norms in the following CAT skill areas: identify additional information needed ($p < .05$; $d = 0.27$), determine whether an invited inference is supported ($p < .05$; $d = 0.26$), and explain how changes in a real-world problem situation might affect the solution ($p < .05$; $d = 0.26$). Negative relationships resulting in large effect sizes were discovered among participants' abilities to identify additional information needed ($p < .05$; $d = 0.88$) and to provide relevant alternative interpretations for a specific set of results ($p < .05$; $d = 0.78$). Further, participants' overall CAT scores ($M = 16.42$; $SD = 4.15$) were significantly lower ($p < .05$; $d = 0.51$) than the upper level CAT national norms ($M = 19.04$; $SD = 6.04$).

Table 3

Results of t-Test for each Skill Area of the CAT as Compared to National Means (n = 75)

E/I ^a	PS ^b	CT ^c	EC ^d	Skill Area Assessed	Institution		National		Diff. ^e	t	df	p ^f	Effect Size ^g
					M	SD	M	SD					
X				Summarize pattern of results.	0.79	0.41	0.67	0.46	0.12	0.09	72	.02*	0.29
				Provide alternatives for spurious associations.	1.59	0.74	1.56	0.86	0.03	0.31	74	.79	0.04
		X	X	Provide alternatives for results.	1.31	0.85	1.35	1.04	-0.04	0.44	74	.72	0.04
	X			Use basic mathematical skills to solve a problem.	0.77	0.42	0.82	0.41	-0.05	0.96	74	.33	0.12
X	X			Separate relevant from irrelevant information.	3.07	1.02	3.14	0.92	-0.07	0.61	73	.50	0.07
X			X	Evaluate strength of correlational-type data.	1.14	1.13	1.21	1.13	-0.07	0.04	73	.57	0.06
X				Evaluate whether information supports a hypothesis.	0.64	0.48	0.73	0.44	-0.09	1.68	73	.07	0.20
X	X			Identify solutions for a problem.	1.07	0.85	1.18	1.03	-0.11	1.14	73	.35	0.12
X				Determine whether an inference is supported by information.	0.56	0.50	0.68	0.41	-0.12	2.08	74	.01*	0.26
X	X		X	Use/apply relevant information.	0.99	0.76	1.11	0.64	-0.12	1.40	74	.10	0.17
	X	X	X	Explain how changes might affect a solution.	0.88	1.04	1.15	1.06	-0.27	2.30	74	.03*	0.26
	X	X	X	Identify additional information.	1.10	1.03	1.41	1.25	-0.31	2.60	73	.04*	0.27
X	X		X	Identify the best solution.	1.98	1.79	2.29	1.81	-0.31	1.49	72	.14	0.17
	X	X	X	Identify additional information.	0.31	0.46	0.82	0.68	-0.51	9.58	74	<.01*	0.88
		X	X	Provide relevant alternative interpretations.	0.41	0.57	0.93	0.74	-0.52	7.83	74	<.01*	0.78
CAT total score					16.42	4.15	19.04	6.04	-2.62	5.48	74	<.01*	0.51

Note. ^a = evaluate and interpret information; ^b = problem solving; ^c = creative thinking; ^d = effective communication; ^e = institution minus national norms; ^f = probability of difference at $p < .05$; ^g = mean difference divided by pooled group SD (0.1 – 0.3 = small; 0.3 – 0.5 = moderate; > 0.5 = large); * = significant at $p < .05$.

The second objective was to explore potential associations among selected student demographic and academic characteristics, and critical thinking abilities. A step-wise multiple regression analysis was conducted to evaluate whether age, sex, semester credit hours, semester GPA, cumulative credit hours, cumulative GPA, total credit hours, and ACT score were necessary to predict overall critical thinking ability as reported by the CAT (Table 4). At step one of the analysis, ACT score was significantly related to overall CAT score ($F(1,64) = 5.798; p < .05$), meaning students with higher ACT scores typically scored higher on the overall CAT. The multiple correlation coefficient was .288, indicating approximately 6.9% of the variance of overall CAT score could be accounted for by the ACT score. Age ($t = 0.190, p > .05$), sex ($t = -1.289, p > .05$), semester hours ($t = 1.269, p > .05$), semester GPA ($t = 1.023, p > .05$), cumulative hours ($t = -1.441, p > .05$), cumulative GPA ($t = 0.717, p > .05$), and total hours ($t = -1.741, p > .05$) did not enter into the equation. Thus, the regression equation for predicting overall CAT score was: Predicted overall CAT score = $0.360 \times \text{ACT score} + 8.810$.

Table 4

Step-wise Regression for Overall CAT Score (N = 66, listwise deletion of missing data)

Variable	B	SE B	β
Constant	8.810	3.248	
ACT	0.360	0.149	.288*

Note. $R^2 = 0.083$; Adjusted $R^2 = 0.069$; $F = 5.798$; * $p < .05$; Excluded variables: Age, Semester Hours, Semester GPA, Cumulative Hours, Cumulative GPA, Total Hours, Sex

Conclusions and Discussion

Recognizing limited research examining the critical thinking abilities of students in colleges of agriculture (Rudd et al., 2000), the purpose of this study was to establish a benchmark for critical thinking abilities of students enrolled within a Department of Agricultural Education and Studies at ISU. Although it is important to recognize the benchmarks proposed in this study are only used in reference to normative data, the benchmarks serve as a point of reference for future critical thinking assessments of agricultural education and studies students enrolled in colleges of agriculture.

The first research objective was to report agricultural education and studies students' critical thinking scores in reference to national user norms. The typical student in this department is a white male between the ages of 21 and 25 who has completed an average of 113 total credit hours and maintained a cumulative GPA average of 2.83 on a 4.00 scale. It should be mentioned CAT national norms are representative of college students across the nation enrolled in a multitude of academic majors and types of academic institutions. Care should be taken when interpreting comparisons to national norms as access to critical values required in determining the degree of similarity between the two populations was restricted (Gall et al., 1996). Findings were primarily intended to serve as a departmental benchmark of current ability in relation to national norm data. Further, the purpose of this benchmark was to evaluate students against the college's critical thinking and problem solving outcome as part of a continuous improvement plan.

Findings from the first research objective led to the conclusion that ISU agricultural education and studies students' possess adequate problem solving abilities, but need more creativity and communicative skill development. Specific to the four broad domains assessed by the CAT, participants performed greatest in the evaluate and interpret information domain, but scored lower than expected in the problem solving domain. Participants were expected to score exceptionally well in their abilities to evaluate and interpret information and solve problems because these two

domains are cornerstones of the academic department in this study as well as core outcomes for the college.

We conclude agricultural education and studies students in this study do not possess strong creative thinking abilities, which mirrors similar research on undergraduate agriculture students (Rudd et al., 2000). Participants also demonstrated room for improvement in the effective communication domain. This domain is of particular interest, due to the high dependence on accurately assessing the open-ended responses utilized in the CAT. Performance on the first three domains relied on participants' abilities to effectively communicate their thought progression in a manner interpretable by an outside evaluator. Were participants' problem solving and creativity abilities actually below expectations or was their performance in these domains more of a reflection of underdeveloped communication skills? Similar to the conclusions of Wagner (2008), discussions during the faculty scoring sessions would suggest the lack of ability to communicate effectively was an issue.

We further conclude college entrance exams remain consistent predictors of critical thinking ability. Findings from the second objective indicated students' ACT scores as the only significant predictor of overall critical thinking ability. This finding closely mirrors the findings of Jacobs (1995) where SAT verbal scores were discovered as the best predictors of critical thinking abilities. The CAT Training Manual (CAIL, 2013) similarly indicated students' scores on the CAT instrument correlate with a significance of $p < .01$ with their scores on the ACT ($r = 0.501$) and SAT ($r = 0.516$).

Due to the conflicting results of this study as compared to previous research findings, sex cannot be definitively considered as a predictor of critical thinking ability. Findings of the third research objective indicated sex was not significantly related to overall critical thinking ability. This finding aligns with the research of Brahmairene and Whitten (2011), Burbach et al. (2012), and Friedel, Irani, and Rhoades et al. (2008). However, it is still at odds with the findings of King et al. (1990), Bers et al. (1996), and Jacobs (1995). Two-thirds of the participants in this study were male, while participants in each of the aforementioned studies were nearly balanced regarding sex. Research exploring the relationship of sex and critical thinking ability within agricultural education is quite the opposite. Instead of the predominately male population found in this study, agricultural education studies, which explored critical thinking, tended to have more females than males in the population (Brisdorf-Rhoades et al., 2005, Friedel, Irani, & Rhoades et al., 2005, Ricketts & Rudd, 2005, Rudd et al., 2000).

Implications and Recommendations

The primary implication for higher education practitioners and curriculum developers stems from the conclusion highlighting students' inability to master critical thinking abilities founded in creative thinking and effective communication. It may be difficult to differentiate whether this challenge originated from a lowered ability to think creatively or a lowered ability to communicate effectively. Regardless, agricultural education faculty should intentionally create activities and utilize pedagogical approaches focusing on developing their students' critical thinking abilities founded in creative thinking, since creative thinking development requires structure and intentionality from instructors and students alike (Robinson, 2001).

A guide for developing such activities and approaches can be found in Duron et al.'s (2006) 5-Step Model for Moving Students Toward Critical Thinking. The model utilizes Bloom's (1956) taxonomy, presuming critical thinking is present when students perform in the *Analysis*, *Synthesis*, and *Evaluation* levels, to assist higher education instructors in the intentional development, integration, and evaluation of critical thinking instruction. The model would first suggest determining learning objectives that facilitate creative thinking and effective communication and then recommend addressing the identified learning outcomes through utilization of active learning techniques, divergent questioning, and interactive discussions. It is also imperative to developing

students' critical thinking abilities that instructors provide feedback and create opportunities for students to engage in self-assessment (Duron et al., 2006).

This same conclusion regarding students' lowered critical thinking abilities founded in creativity and communication also possesses implications for future research. The agricultural education department in this study is comprised of three independent academic majors/options. However, this study did not explore differences in critical thinking ability according to academic major/option. Future research should be conducted by agricultural education faculty representing a variety of specific academic majors to explore the role major possesses on critical thinking development. More importantly, future agricultural education research should closely examine the effects specific curricula, courses, and activities have on critical thinking development. Are certain agricultural education courses or activities more successful at developing critical thinking specifically founded in creativity and communication? If so, what makes these courses or activities different than others? Intensive research efforts conducted at the departmental or collegiate level should also be directed toward longitudinal studies exploring the development of agricultural education students' critical thinking abilities throughout the course of their higher education experience.

The conclusion asserting students' evaluative, interpretative, and problem solving abilities possesses implications surrounding the intentionality of teaching. Agricultural education students' current level of evaluation, interpretation, and problem solving abilities could be assumed the result of departmental-wide recognition of the importance of these domains and, therefore, be representative of intentionality to teach them. It could also be interpreted as a lack of intentionality directed toward creative thinking and effective communication. However, it could also be representative of a misalignment between the educational outcomes valued by the department and those assessed by the CAT. A closer look at the abilities measured by the assessment tool utilized in this study is recommended to ensure alignment with educational outcomes identified by the academic department's faculty.

All higher education faculty should recognize the changing dynamics of their students as well as the new skill sets these students need to be successful in education and life. Innovative teaching methods and best practices targeting specific components of critical thinking need to make it to the forefront of higher education. Instructors at all levels should become critically reflective of their own teaching methods and create learning activities that progressively advance students toward higher order thinking skills. Depending upon comprehensive critical thinking knowledge level, higher education faculty should either participate in or conduct professional development activities in not only the broad sense of critical thinking, but in the specific domain of effective communication as well. Higher education instructors must continue to provide an education that will prepare students for success in an ever-changing society.

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