The Impact of a Capstone Farm Management Course on Critical Thinking Abilities

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Abstract

Current research demonstrates a need to explore the effects of specific course designs or directed activities on higher education students' critical thinking abilities. Specifically, such research on the effect of an experiential learning-based capstone course is limited. All students (N = 54) enrolled in a capstone farm management course completed a critical thinking assessment test through a pretest–posttest design, and 25 of the paired tests were analyzed using t tests. Although there were no statistically significant increases for overall critical thinking scores, there was a significant increase in one subskill: Summarize a pattern of results in a graph. The capstone course in this study may emphasize only certain subskills of critical thinking development while negating to address others. The key implication for instructors of similar capstone courses is to be intentional in targeting development of the wide array of specific skills shown to affect overall critical thinking abilities.

Keywords: capstone course; critical thinking; problem solving

Critical thinking is a fundamental, overarching outcome of higher education meant to help students to learn how to improve their thinking (Willsen, 1995). Faculty members perceive that responsibility for helping students develop higher-order thinking skills is among higher education's primary teaching roles (Cross, 1993). In as little as one semester, well-prepared higher education faculty can influence students' critical thinking dispositions (Burbach, Matkin, Quinn, & Searle, 2012) and overall critical thinking abilities (Felder & Brent, 2010). Thus, higher education faculty members need to acquire and maintain a comprehensive understanding of critical thinking. Yet there is a general lack of critical thinking knowledge among teaching faculty (Stedman & Adams, 2012) and little evidence that critical thinking development occurs in collegiate classrooms (Tsui, 2001).

Perhaps this general lack of critical thinking knowledge among teaching faculty (Stedman & Adams, 2012) can be attributed to difficulties in defining critical thinking. Higher education serves as the host for a robust debate surrounding what constitutes critical thinking (Possin, 2008). At its core level, critical thinking is the ability to analyze and evaluate information (Duron, Limbach, & Waugh, 2006). Critical thinking is purposeful, outcome-based thinking driven by professional standards (Popil, 2011). It is perceived as "an abstract, generalizable, learned, rational process, synonymous with decision making" (Gordon, 2000, p. 346). In the context of agricultural

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education, critical thinking is defined as "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" (Rudd, Baker, & Hoover, 2000, p. 5).

> Critical thinking typically involves the ability to do some or all of the following: Identify central issues and assumptions in an argument, recognize important relationships, make correct inferences from data, deduce conclusions from information or data provided, interpret whether conclusions are warranted on the basis of the data given, and evaluate evidence or authority. (Pascarella & Terenzini, 1991, p. 118)

Critical thinkers possess a set of affective dispositions that enable them to address situations that require higher-order thinking (Facione, 1990). These dispositions include inquisitiveness, concern, alertness, trust, self-confidence, open-mindedness, flexibility, understanding, fair-mindedness, honesty, prudence, and willingness to reconsider and revise views when reflection suggests change is warranted (Facione, 1990). Individuals are more effective thinkers if they exhibit these affective dispositions (Rudd, 2007).

One of the most common instructional techniques that positively affects students' critical thinking abilities is active learning (Duron et al., 2006; Popil, 2011; Tsui, 2002; Yang, 2012; Youngblood & Beitz, 2001). In active learning environments, the instructor acts as a facilitator of learning, allowing for an emphasis on deep learning and student accountability (Biggs, 1999). Students who are taught using active learning techniques are better able to address questions that require the use of higher-order thinking skills (Richmond & Hagan, 2011). Some active learning approaches that increase student understanding include immediate feedback assessment (Lee & Jabot, 2011); student-led debates (Roy, 2012); and the 1-minute paper, wherein students state the main, most clear, or muddiest point in the lecture (Adrian, 2010). Experiential learning, also categorized as active learning, provides students an opportunity to make substantial gains in critical thinking (Duron et al., 2006).

The experiential learning process "requires an initial focus of the learner, followed by an interaction with the phenomenon being studied, reflecting on the experience, developing generalizations, and then testing those generalizations" (Roberts, 2006, p. 27). Experiential learning models provide solid, theoretical foundations for a capstone course (Andreasen, 2004), which is an in-depth study, grounded in a particular discipline, that goes beyond the limitations of the current curriculum (Wagenaar, 1993). Specifically, a capstone learning experience is one that cultivates critical thinking, problem solving, decision making, teamwork, and communication through the use of multidisciplinary approaches (Crunkilton, Cepica, & Fluker, 1997; Kranz, 1991). If higher education faculty possess the ability to improve students' critical thinking abilities (Burbach et al., 2012; Felder & Brent, 2010), and if capstone courses founded in experiential learning target critical thinking development (Crunkilton et al., 1997; Kranz, 1991), can a semester-long capstone course increase students' critical thinking abilities?

Conceptual Framework

According to Andreasen (1998), there is an extensive gap in capstone course literature linking experiential learning activities to the curricula. To address this gap, Andreasen (1998) developed the model for integration of experiential learning into capstone courses (MIELCC; Figure 1). This model provided a conceptual framework for the present study. The MIELCC's starting point uses Crunkilton et al.'s (1997) notion that one purpose of a capstone course is to unify the fragmented disciplinary knowledge obtained from an educational process through a specific set of learning activities and instructional techniques including teamwork, problem solving, decision making, critical thinking, and communication (Andreasen, 1998).

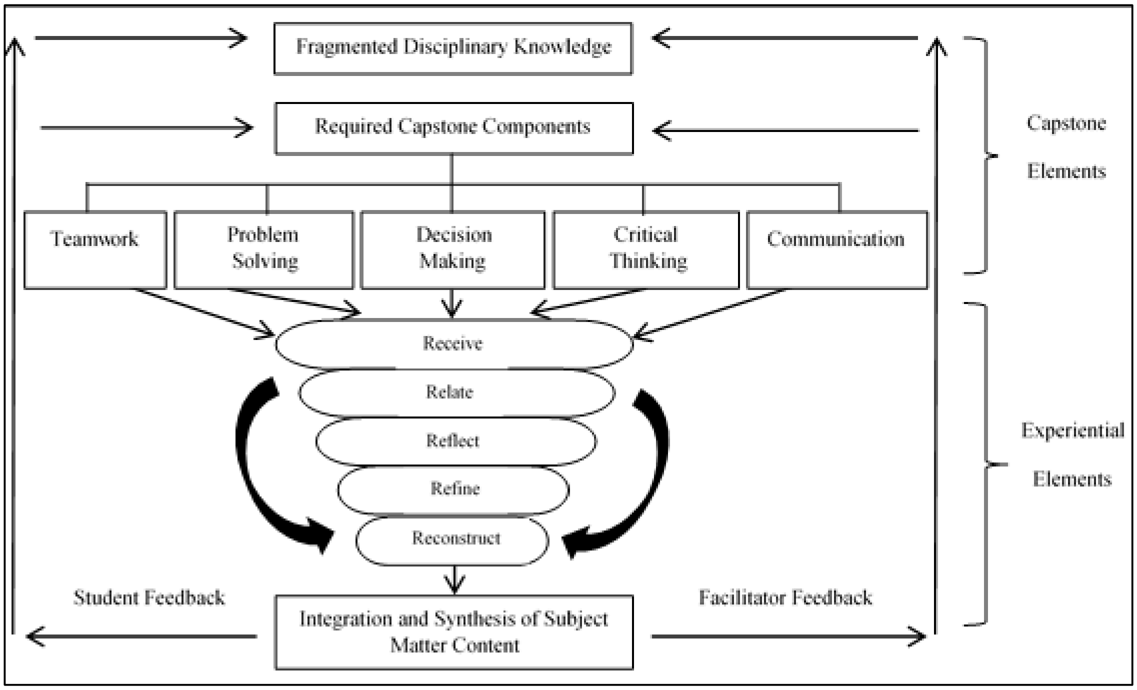

Figure 1. Model for integration of experiential learning into capstone courses (MIELCC). From "Integrating Experiential Learning into College of Agriculture Capstone Courses: Implications and Applications for Practitioners," by R. J. Andreasen, 2004, *NACTA Journal*, *48*(1), p. 55. Copyright 1999 by R.J Andreasen. Reprinted with permission.

The next section of the MIELCC integrates several major theories of experiential learning in which receiving, relating, reflecting, refining, and reconstructing information (the five R's) act as a funnel to synthesize content (Andreasen, 1998). The first R, receive, refers to an activity or experience either created by the instructor or experienced spontaneously by the student (Andreasen, 1998). The receiving stage corresponds to the concrete experiences referred to by models conceptualized by Lewin (1951), Piaget (1971), and Kolb (1984). The next R, relate, is concerned with linking learned experiences to previously gained knowledge to better integrate experiential learning into capstone course philosophy (Andreasen, 1998). Other experiential learning models refer to this step as internalized reflection (Piaget, 1971), reflective observation (Kolb, 1984), or sharing and processing (Cooperative State Research, Education, and Extension Service [CSREES], 1992).

The third R, reflect, occurs when students purposefully reflect on experiences received and begin to relate them to other scenarios (Andreasen, 1998). Experiential learning becomes distinguishable from learning through experiences in the reflection and relation of experiences (Andreasen, 1998). The fourth R, refine, is characterized by a process in which students contemplate the applicability of newly attained knowledge and its association to previously attained knowledge (Andreasen, 1998). The final R, reconstruct, allows students to synthesize content so they can integrate it into useable knowledge and apply it to different situations or practices (Andreasen, 1998). The MIELCC concludes in a cyclical manner wherein student and facilitator feedback advert back to the original starting point of the model, fragmented disciplinary knowledge. The newly found knowledge resulting from the process is then added back with other similar or conflicting knowledge and reprocessed.

Higher education research details the importance of developing students' critical thinking abilities (Burbach et al., 2012; Cross, 1993; Felder & Brent, 2010; Willsen, 1995) as well as the apparent lack of comprehensive critical thinking understanding occurring in collegiate classrooms (Stedman & Adams, 2012; Tsui, 2001). Active learning is a popular method of increasing students' critical thinking abilities (Duron et al., 2006; Popil, 2011; Tsui, 2002; Yang, 2012; Youngblood & Beitz, 2001). Capstone courses are an example of situations where active learning often occurs. In addition, capstone courses, which are based on experiential learning models, are meant to target students' critical thinking abilities (Crunkilton et al., 1997; Kranz, 1991).

For example, the capstone farm management course at Iowa State University (AgEdS 450) provides graduating seniors in a production agriculture major the opportunity to gain working knowledge or training in at least four content areas: (a) farm practices; (b) scientific principles of crop and animal production, including the use of power equipment and machinery; (c) business principles of farming; and (d) making management decisions (Murray, 1945). AgEdS 450 allows students the opportunity to apply technical content knowledge as well as skills in production, financial management, marketing, and human relations to the daily operation and long-term strategic management of an agricultural business. Derived from Crunkilton et al.'s (1997) recommendations, educational outcomes of AgEdS 450 include teamwork, problem solving, critical thinking, communication, and decision making. Specific course activities designed to enhance critical thinking include written reports (Tsui, 2002), issues analysis (Pascarella & Terenzini, 1991), oral presentations (Wagner, 2008), industry involvement, and active learning tasks (Richmond & Hagan, 2011) associated with the upkeep, maintenance, and management of the farm. However, a question remains: Does this experiential learning-based capstone course positively influence students' critical thinking abilities?

Purpose and Objectives

This study was part of a larger investigation and designed to explore the impact of Iowa State University's semester-long capstone farm management course on the development of undergraduate agricultural education and studies students' critical thinking abilities. This purpose aligns with the American Association for Agricultural Education's National Research Agenda Research Priority Area 4: Meaningful, Engaged Learning in All Environments (Doerfert, 2011). This study had two objectives:

1. Determine if there were significant changes in the critical thinking abilities of students enrolled in AgEdS 450 over a period of one semester.
2. Compare AgEdS 450 students' critical thinking abilities to national norm data.

Methods and Procedures

The population for this study was all undergraduate students enrolled in AgEdS 450 during the spring 2013 semester (N = 54). The course had one combined lecture with two separate laboratory sections; each laboratory section met once a week at the farm for 4 hours (Paulsen, 2013). There was one primary instructor for the lecture and both laboratory sections. Demographic and academic characteristics of all students (N = 54) enrolled in AgEdS 450 were compared by laboratory section. A Pearson's χ^2 analysis yielded no significant difference (p > .05) between laboratory sections for gender, and a two sample t test yielded no significance differences (p > .05) for age, semester hours completed, semester grade point average (GPA), cumulative hours, cumulative GPA, total hours, or ACT score. Therefore, the following discussion refers to the entire capstone course as opposed to the individual laboratory sections.

A matched-pairs pretest–posttest design was used for this study. Several studies have used a pretest–posttest design to evaluate the effects of an educational experience on the development of students' critical thinking abilities (Bers, McGowen, & Rubin, 1996; Friedel et al., 2008; Iwaoka, Li, & Rhee, 2010). In this study, students' critical thinking abilities were assessed using the Critical Thinking Assessment Test (CAT), a non-discipline specific National Science Foundation-supported tool created to assess and improve critical thinking skills. The CAT was selected as the assessment instrument because of its use of open-ended responses as well as its record of national reference norms. The pretests and posttests were administered separately in each of the two laboratory sections during weeks 1 and 15 of the 16-week semester. Of the paired tests administered (*N* = 54), 45 matched pairs were compiled. Because of limited resources, primarily faculty scorers' time, it was necessary to pare down the quantity of assessments scored. Although the Center for Assessment and Improvement of Learning ([CAIL], 2013), creator of the CAT, determined a minimum of 10 matched pairs to be sufficient in evaluating changes in critical thinking abilities through a pretest–posttest design, available resources allowed 15 additional (*n* = 25) paired assessments (12 from laboratory section one and 13 from section two) to be randomly selected and scored for this study.

The CAT includes 15 short-answer questions based on real-world situations developed to accurately assess important components of critical thinking, such as effective communication, the ability to evaluate and interpret information, problem solving, and creative thinking (CAIL, 2010). Ten Iowa State University faculty scored the CAT assessments under direct supervision of CAIL-trained representatives. Detailed scoring rubrics provided by CAIL were used to enhance consistency and reliability in evaluations. Among other uses, the CAT is designed to evaluate the effects of a specific course through a pretest–posttest design (CAIL, 2012). The 15 specific skill areas assessed by the CAT instrument (Figure 2) were developed by an interdisciplinary team of faculty and validated by faculty representing various institutions (CAIL, 2013), thus establishing face validity.

Specific Skill Areas Assessed by the Critical Thinking Assessment Test	
• 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	• 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. Specific skill areas assessed by the Critical Thinking Assessment Test (CAIL, 2012).

CAIL (2010) reported inter-rater reliability examinations on the CAT at the level of .82 and a test-retest reliability coefficient of greater than .80 (CAIL, 2012). Gall, Gall, and Borg (1996) claim reliability coefficients of .80 or higher are "sufficiently reliable" (p. 200). Inter-rater reliability was further established by having at least two faculty scorers score each question. If the initial two scorers disagreed, a third scorer scored the question. 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 tests scored. Overall accuracy was well within the allowable margin of error, ensuring the scores were valid for comparison to national norms.

Demographic and academic characteristics were obtained from the Office of the Registrar and were described by measures of central tendency. University-specific terminology was used to describe students' academic characteristics. Semester credit hours included the amount 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 amount of credit hours taken at the current university, and cumulative GPA reflected the GPA of these credit hours. Total credit hours was the sum of all credit hours taken at the current university and any credit hours transferred from other institutions.

The *t* distribution was used to determine the level of statistical significance of an observed difference between sample means among small samples sizes ($n < 30$) (Gall et al., 1996). Per typical educational research, statistical significance was set a priori at $p < .05$ (Gall et al., 1996). To address the first objective, paired-samples *t* tests were used to determine if enrollment in AgEdS 450 for a single semester made a statistically significant difference ($p < .05$) in students' critical thinking abilities. To address the second objective, a one-sample *t* test using CAT national norm data collected from junior- and senior-level higher education students across the nation was conducted. Students' posttest scores were used for this comparison to take into account any effects of enrollment in AgEdS 450. Effect sizes quantifying group differences were interpreted using Cohen's (1992) criteria, wherein 0.02 is considered small, 0.15 is medium, and 0.35 is large.

Data were representative of a homogenous sample in regard to educational degree pursuit. Therefore, use care when extrapolating results beyond students enrolled in AgEdS 450. However, these data offer insight for other institutions regarding factors that influence undergraduate students' critical thinking abilities.

Results

Seventy-six percent ($n = 19$) of students were male, and 24.0% ($n = 6$) were female. All students ($n = 25$) were between the ages of 21 and 25. All students ($n = 25$) self-identified themselves as white. The typical participant was enrolled in an average of 14.86 ($SD = 1.99$) semester credit hours and had an average semester GPA of 2.73 ($SD = 0.61$) on a 4.00 scale. The average amount of total credit hours completed was 110.42 ($SD = 12.39$) with an average cumulative GPA of 2.64 ($SD = 0.49$) on a 4.00 scale. The average ACT score of those reporting was 21.07 ($SD = 3.01$).

The first objective sought to determine if there were significant changes in students' critical thinking and problem solving abilities over a period of one semester. Multiple paired-samples *t* tests were conducted to compare pre-course and post-course critical thinking and problem solving abilities according to the 15 specific skill areas assessed by the CAT (Table 1). The only skill area with a statistically significant difference ($p = .02$; $d = 0.44$, large) between pretest and posttest scores was the ability to summarize the pattern of results in a graph without making inappropriate inferences.

The second objective was to compare students' posttest scores with CAT national norm data (Table 2). The only skill area for which students scored significantly higher ($p = .01$; $d = 0.47$, large) than CAT national norm data was the ability to separate relevant from irrelevant information when solving a real-world problem. Students scored statistically lower ($p < .01$) than CAT national norm data in the skill areas of identifying additional information needed to evaluate a hypothesis ($d = 1.14$, large) and providing relevant alternative interpretations for a specific set of results ($d = 0.68$, large). Students' overall CAT score was significantly lower ($p < .01$, $d = 0.50$, large) than CAT national norm data.

Table 1

Results of Paired Samples t Test of Students Enrolled in AgEdS 450 (n = 25)

	Pretest			Posttest							Effect
Skill area assessed	*M*	*SD*	%[a]	*M*	*SD*	%[a]	Diff.[b]	*t*	*df*	*p*[c]	size[d]
Give alternatives for a pattern of results.	1.04	0.93	35.0	1.48	0.96	49.0	0.44	2.03	24	.05	0.46
Separate relevant from irrelevant information when solving a problem.	3.28	0.74	82.0	3.52	0.71	88.0	0.24	1.24	24	.23	0.33
ummarize pattern of results in a graph.	0.60	0.50	60.0	0.80	0.41	80.0	0.20	2.45	24	.02*	0.44
Determine whether an invited inference is supported by specific information.	0.48	0.51	48.0	0.68	0.48	68.0	0.20	1.73	24	.10	0.41
Evaluate strength of correlational-type data.	1.04	1.06	35.0	1.08	1.06	36.0	0.13	0.44	23	.66	0.04
Provide relevant alternative interpretations for a specific set of results.	0.36	0.49	18.0	0.48	0.59	24.0	0.12	1.00	24	.33	0.22
Give alternatives for spurious associations.	1.44	0.82	48.0	1.56	0.71	52.0	0.12	0.53	24	.60	0.16
Identify suitable solutions for a real-world problem using relevant information.	0.88	0.83	29.0	1.00	0.91	33.0	0.12	0.68	24	.50	0.14
Use basic mathematical skills to help solve a real-world problem.	0.88	0.33	88.0	0.92	0.28	92.0	0.04	1.00	24	.33	0.13
Evaluate whether spurious information strongly supports a hypothesis.	0.79	0.41	79.0	0.71	0.46	71.0	-0.04	0.37	22	.71	0.19
Use/apply relevant information.	0.96	0.61	48.0	0.84	0.75	42.0	-0.12	0.72	24	.48	0.18
Explain how changes in a problem situation might affect the solution.	0.92	1.04	31.0	0.79	1.14	26.0	-0.13	0.48	24	.64	0.12
Identify and explain the best solution for a real-world problem.	1.83	2.08	37.0	1.59	1.88	32.0	-0.26	0.55	23	.59	0.12
Identify additional information needed to evaluate a hypothesis.	1.32	1.14	33.0	1.05	1.15	26.0	-0.27	0.83	24	.41	0.23
Identify additional information needed.	0.48	0.59	24.0	0.20	0.41	10.0	-0.28	1.90	24	.07	0.56
CAT total score	16.20	4.60	43.0	16.63	3.62	44.0	0.43	0.53	24	.60	0.10

[a]Average percentage of attainable points per skill area; [b]Posttest minus pretest; [c]Probability of difference; [d]Mean difference divided by pooled group *SD* (0.02 = small; 0.3 – 0.15 = moderate; > 0.35 = large).
* $p < .05$.

Table 2

Results of t Test of Students Enrolled in AgEdS 450 Compared to National Norm Data (n = 25)

Skill area assessed	Posttest *M*	Posttest *SD*	Posttest %[a]	National *M*	National *SD*	National %[a]	Diff.[b]	*t*	*df*	*p*[c]	Effect size[d]
Separate relevant from irrelevant information when solving a problem.	3.52	0.71	88.0	3.14	0.92	78.5	0.38	2.66	24	0.01*	0.47
Summarize pattern of results in a graph without making inappropriate inferences.	0.80	0.41	80.0	0.67	0.46	67.0	0.13	1.59	24	0.12	0.30
Give alternatives for a pattern of results.	1.48	0.96	49.0	1.35	1.04	45.0	0.13	0.68	24	0.51	0.13
Use basic mathematical skills to help solve a real-world problem.	0.92	0.28	92.0	0.82	0.41	82.0	0.10	1.80	24	0.08	0.29
Give alternatives for spurious associations.	1.56	0.71	52.0	1.56	0.86	52.0	0.00	0.00	24	1.00	0.00
Determine whether an invited inference is supported by specific information.	0.68	0.48	68.0	0.68	0.41	68.0	0.00	0.00	24	1.00	0.00
Evaluate whether spurious information strongly supports a hypothesis.	0.71	0.46	71.0	0.73	0.44	73.0	-0.02	0.23	23	0.82	0.04
Evaluate strength of correlational-type data.	1.08	1.06	36.0	1.21	1.13	40.3	-0.13	0.59	23	0.56	0.12
Identify suitable solutions for a real-world problem using relevant information.	1.00	0.91	33.0	1.18	1.03	39.3	-0.18	0.99	24	0.33	0.19
Use/apply relevant information.	0.84	0.75	42.0	1.11	0.64	55.5	-0.27	1.81	24	0.08	0.39
Explain how changes in a problem situation might affect the solution.	0.79	1.14	26.0	1.15	1.06	38.3	-0.36	1.59	24	0.13	0.33
Identify additional information needed to evaluate a hypothesis.	1.05	1.15	26.0	1.41	1.25	35.3	-0.36	1.55	24	0.13	0.30
Provide relevant alternative interpretations.	0.48	0.59	24.0	0.93	0.74	46.5	-0.45	3.84	24	<.01*	0.68
Identify additional information needed.	0.20	0.41	10.0	0.82	0.68	41.0	-0.62	7.60	24	<.01*	1.14
Identify and explain the best solution for a real-world problem.	1.59	1.88	32.0	2.29	1.81	45.8	-0.70	1.87	24	0.07	0.38
CAT total score	16.63	3.62	44.0	19.04	6.04	50.1	-2.41	3.33	24	<.01*	0.50

[a]Average percentage of attainable points per skill area; [b]Posttest minus pretest; [c]Probability of difference; [d]Mean difference divided by pooled group *SD* (0.02 = small; 0.3 – 0.15 = moderate; > 0.35 = large).
* $p < .05$.

Conclusions and Discussion

Reflective of the critical thinking abilities identified by Pascarella and Terenzini (1991), our primary conclusion from this study is that enrollment in a semester-long capstone farm management course can positively influence students' abilities to recognize important relationships and make correct inferences from data. We also conclude that enrollment in AgEdS 450 does not improve students' overall critical thinking ability. There were no statistically significant changes between overall pretest–posttest scores. These findings align with those of Iwaoka et al. (2010), who found no significant differences among overall critical thinking pretest–posttest scores in a semester-long food science course. Perhaps the lack of overall critical thinking improvement can be attributed to the specificity of the skill areas assessed by the CAT. Although the CAT is a valid, reliable instrument, critical thinking is a complex concept not easily assessed by a singular instrument. AgEdS 450 may also facilitate critical thinking development in areas not assessed by the CAT, such as those more closely aligned with the critical thinking affective dispositions.

Although enrollment in AgEdS 450 does not improve overall critical thinking ability, enrollment does increase certain skill areas that influence overall critical thinking ability. Specifically, enrollment in AgEdS 450 reinforces students' abilities to separate relevant from irrelevant information. This conclusion is reassuring because according to Andreasen's (1998) MIELCC, receiving information and solving problems are integral elements of experiential learning and capstone courses.

Students in AgEdS 450 scored significantly higher than national CAT norms in terms of their ability to separate relevant from irrelevant information when solving real-world problems. However, students performed statistically below the national norms in regard to their ability to identify additional information needed to evaluate a hypothesis and to provide relevant alternative interpretations for a specific set of results.

It is important to remember that CAT national norm data are from students representing a variety of higher education institutions across the nation and a multitude of academic majors. Use caution when interpreting comparisons to national norms because access to critical values required to determine the degree of similarity between the two populations was restricted (Gall et al., 1996). And in all but two cases—separating relevant from irrelevant information and using basic mathematical skills to solve a problem—students' pretest scores were already below CAT national norms. Exceptional increases in critical thinking ability would have been required to advance the posttest scores above the CAT national norms.

AgEdS 450 uses numerous instructional approaches, in which critical thinking is crucial, to accomplish the intended learning outcomes. Specific approaches directed toward enhancing students' critical thinking abilities include, but are not limited to, student discussions (Tsui, 2002; Yang, 2012), written (Tsui, 2002) and oral communication (Wagner, 2008), and issues analysis (Pascarella & Terenzini, 1991). These approaches align with Crunkilton et al.'s (1997) required learning activities of a capstone course, so we anticipated increases in students' overall critical thinking abilities. However, Andreasen's (1998) MIELCC incorporates these learning activities and implies that students in capstone courses must use critical thinking, decision making, problem solving, and communications to create new ideas that integrate and synthesize subject matter content. Therefore, achieving the outcomes of a capstone course may not be solely represented in the form of increases in overall critical thinking ability, but also by increases in decision making, problem solving, and communication abilities. Because the CAT is a short-answer assessment, written communication abilities influence a significant portion of students' measured critical thinking and problem solving abilities.

A capstone course is a complex system that uses multiple instructional frameworks to move students toward the construction of new knowledge. Thus, increases in any skill area associated with overall critical thinking abilities speak to outcomes attained from the course. Crunkilton et al. (1997) identified teamwork, problem solving, critical thinking, communications, and decision making as intended outcomes of capstone courses. Even if students' overall critical thinking abilities do not increase over the span of one semester, are capstone courses, such as AgEdS 450, achieving the intended outcomes identified by Crunkilton et al. (1997)? Other broader outcomes may have been achieved but not measured in this study (e.g., the CAT does not assess teamwork). More importantly, the original focus of capstone course instructors to create curricula that targeted multiple intended outcomes may have shifted to a content-specific outcome. What can instructors do to help their students develop critical thinking abilities in these settings?

Implications and Recommendations

Conclusions from this study have implications for professional development, curriculum development, and academic research. Enrollment in AgEdS 450 did not significantly affect students' overall critical thinking abilities, so instructors of similar capstone courses should take time to analyze and evaluate their teaching methods and approaches to ensure they are addressing critical thinking learning outcomes. In particular, instructors of capstone farm management courses who strive to increase students' critical thinking abilities should be intentional in targeting the development of critical thinking abilities. This targeted development requires instructors to intentionally "(a) review current literature and pedagogy associated with critical thinking; (b) integrate critical thinking pedagogy into courses; (c) overtly teach critical thinking skills and dispositions; and (d) engage in peer support and opportunities for shared learning" (Burbach et al., 2012, p. 9).

Instructors of capstone farm management courses should participate in professional development opportunities that specifically address teaching strategies for integrating and overtly teaching critical thinking. Specifically, these instructors should be intentional in creating and using activities that continually demonstrate critical thinking development among students, such as student-centered discussions (Tsui, 2002; Yang, 2012), written (Tsui, 2002) and oral (Wagner, 2008) communication projects, and issues analyses (Pascarella & Terenzini, 1991).

Implications for curriculum development stem from our conclusions that AgEdS 450 emphasized certain aspects of critical thinking development while negating to address others. Therefore, instructors should review their capstone course curriculum to ensure it explicitly includes activities that directly target an array of critical thinking abilities as well as affective dispositions; such dispositions enable students to address situations that require higher-order thinking (Facione, 1990).

Implications for research emerge from our conclusion that enrollment in AgEdS 450 does not significantly affect students' overall critical thinking abilities. Agricultural education researchers should expand on this study to determine effective means of increasing students' critical thinking abilities in capstone farm management courses. However, researchers should examine and consider the timing of both the pretest and posttest before replicating this study. A lack of student motivation and effort may have been present during the posttest because it was administered during the second to last week of the course, which was the last semester of college for many of the students. Students' overall excitement and anxiety about nearing graduation dates might have affected their willingness to perform on the posttest, especially because the test did not affect their course grade (Wolf & Smith, 1995).

AgEdS 450 provides a unique opportunity for experimental design research because it has two laboratory sections. Altering instructional approaches for one section while using the other section as a control group could provide more insight to effective strategies for capstone farm management courses. Also, using different assessment instruments could provide a more holistic view of what specific critical thinking skill areas are being developed in a capstone course, regardless of discipline. A multiyear, longitudinal study conducted by instructors of capstone farm management courses could provide a means of tracking these instructional alterations and the associated student learning effects.

We also recommend conducting qualitative research to explore how agricultural education students view critical thinking. Research should explore how much agricultural education students actually value the skills associated with critical thinking. This could in turn lead to research exploring how potential increases in critical thinking development are associated with skills that students value. Because critical thinking is a complex system, future research should focus on additional factors that affect critical thinking development, such as past experiences. Specifically, research should examine the influence of students' past experiences to facilitate critical thinking.

Agricultural education faculty and instructors need to consider these recommendations for professional development, curriculum development, and research to advance the study of critical thinking development within our discipline and within higher education.

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