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Exploring critical thinking skills among undergraduate agriculture education and studies students

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ABSTRACT

The purpose of this dissertation was to describe the current critical thinking abilities of undergraduate agriculture education and studies students, and to explore how entry pathway and enrollment in a capstone course affect these abilities. Objectives were to: (1) establish a departmental benchmark for the critical thinking abilities of senior-level agricultural education and studies students; (2) determine if entry pathway, direct from high school admittance versus transfer from community college admittance, has an effect on critical thinking abilities; and (3) examine the impact a semester-long capstone farm management course has on the development of critical thinking abilities.

For objectives one and two, 75 senior-level undergraduates in the Department of Agricultural Education and Studies at Iowa State University were randomly selected to complete a critical thinking assessment test during spring 2013 semester. *T*-tests and a step-wise regression model analyzing predictors of critical thinking ability were used to analyze data. For objective three, paired sample *t*-tests were used to determine differences in 25 students' pre- and post-test scores in a capstone farm management course.

Overall, students performed greatest in their abilities to evaluate and interpret information, but were unable to master critical thinking abilities founded in creative thinking and effective communications. Step-wise regression for total critical thinking scores revealed the ACT score as the only significant predictor of overall critical thinking ability. Students' overall critical thinking abilities were not significantly influenced by entry pathway or enrollment in the semester-long capstone farm management course. However, enrollment in the capstone course positively influenced students' abilities to summarize patterns of results in a graph.

CHAPTER I. INTRODUCTION

The ability to think critically is a valued personal and professional life skill. The recognition of the importance of critical thinking is evident in recent higher education reform where the purposeful decision to nurture and develop students' critical thinking abilities is among the most valued outcomes of higher education institutions. Instructional approaches shown to positively influence students' critical thinking abilities, such as learner-centered environments, have been gaining popularity in higher education and numerous critical thinking assessments have emerged as a result. Yet, much debate still surrounds the discussion regarding the most effective means to cultivate and assess critical thinking. This chapter provides background that establishes a foundation for understanding the complexities associated with critical thinking in higher education. Further, a statement of the problem, a description of the research objectives, definition of terms, and an overview of the significance of the study are provided.

Background and Setting

A new age of unlimited information and subsequent information overload has prompted a reexamination of the necessary skills required to be successful in academic and life explorations. These skills, known as 21st century skills, include critical thinking (Wagner, 2008). Critical thinking is seen as a fundamental, overarching outcome of education meant to teach students how to improve their thinking (Willsen, 1995). Yet, too great of an emphasis is still placed on standardized achievement tests, grades, and other similar evaluation measures (Heckman & Kautz, 2012). This emphasis on standardization would imply standardized test scores and grade point averages (GPA's) are sought- after traits in recent graduates. This does not seem to be the case. In fact, employers consistently rank GPA and awards as items of little importance (Norwood & Henneberry, 2006), but recognize the importance of both the cognitive and dispositional dimensions of critical thinking (Papadopoulos, 2010). Higher education must prepare students with 21st century skills such as critical thinking, problem solving, and communication that can transcend disciplines (Rhodes, Miller, & Edgar, 2012; Wright, 1992).

A general lack of understanding surrounds what constitutes critical thinking (Stedman & Adams, 2012). Many instructors believe they employ pedagogies that encourage critical thinking among their students. However, these instructors may mistake students' abilities to think logically and solve problems as critical thinking development when, in fact, it could simply be the manner in which the students come to understand the concepts (Choy & Cheah, 2009). The overlap between critical thinking and problem solving can be somewhat confusing, as total critical thinking disposition is not correlated with total problem solving style (Friedel, Irani, Rhoades, Fuhrman, & Gallo, 2008). However, "a student's preference to solve problems by generating many solutions and employing a strategy of thoroughness and attention to detail is associated with a higher critical thinking disposition" (Friedel, Irani, Rhoades et al., 2008, p. 34).

In its most simplistic form, critical thinkers are those who possess the ability to analyze and evaluate information (Duron, Limbach, & Waugh, 2006). "Critical thinking 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" (Rudd, Baker, & Hoover, 2000, p. 5). Regardless of which definition or theoretical basis one prefers, "critical thinking is indispensable for 21st century teaching and learning" (Yang, 2012, p. 1129).

Alterations in instruction and assessment approaches are emerging to address the changing skill set required to be successful in the 21st century. The traditional, instructor-centered curriculum is being replaced with a learner-centered curriculum more focused on the individual (Brown, 2003). Unlike instructor-centered approaches where knowledge is simply transmitted from instructor to student, learner-centered instruction allows students to construct knowledge by gathering and synthesizing information through inquiry, communication, critical thinking, and problem solving (Huba & Freed, 2000). Learner-centered assessment intertwines with teaching and promotes and diagnoses learning (Huba & Freed, 2000). Thus, learner-centered assessment places more of an emphasis on outcomes of learning as a dynamic process. Paul (1995) cautions "to formulate substantial outcomes in such a way that we can truly assess whether they are being achieved requires critical thinking in the design and application of the teaching and assessment process" (p. 45).

Learner-centered instruction and assessment approaches demonstrate positive effects on students' critical thinking abilities. Learner-centered instruction and assessment approaches include: (1) actively engaging students in the learning process, (2) utilizing divergent questioning, and (3) students' participation in class discussions (Duron et al., 2006; Yang, 2012). Specific approaches that demonstrate positive effects on students' critical thinking abilities include experiential learning (Duron et al., 2006), case studies (Popil, 2011), and writing and re-writing activities (Tsui, 2002). On the other hand, employing lecture as a primary delivery method (Duron et al., 2006), utilizing convergent questioning (Duron et al., 2006), and requiring rote memorization (Choy &

Cheah, 2009; Yang, 2012) do not demonstrate positive effects on students' critical thinking abilities.

With the recent gravitation toward learner-centered outcomes, higher education needs "instructional policies and practices that directly affect how much and how well students learn" (Weimer, 2013, p. vii). The Association of American Colleges and Universities (AACU) (2004, 2007, 2010) recognized critical thinking and problem solving among a set of outcomes valued by universities. Similarly, Iowa State University (ISU) created student outcomes that state undergraduate students are expected to "improve their general intellectual skills, to attain proficiency in one or more academic disciplines of their choice, and to develop interpersonal and leadership skills needed for productive careers and effective citizenship" (Center for Excellence in Teaching and Learning [CELT], 2001).

More specifically, the College of Agriculture and Life Sciences (CALS) at ISU identified seven learning outcomes expected of students who earn a baccalaureate degree from the college. The CALS outcomes are (1) professional, interpersonal and cross-cultural communications, (2) problem solving and critical thinking, (3) leadership, (4) entrepreneurship, (5) life-long learning, (6) ethics, and (7) environmental awareness (ISU, 2012).

The critical thinking and problem solving outcome is specific to this study. CALS further elaborated on the critical thinking and problem solving outcome (ISU, 2012) to reflect the importance of graduates demonstrating their ability in:

> Applying holistic approaches to solving complex issue-laden problems. Applying rational and objective processes to: distinguish verifiable facts from value claims,

> determine the accuracy of statements, identify assumptions and detect bias, distinguish relevant from irrelevant information, and prioritize needs. Summarizing, analyzing, and interpreting simple research data and policy issues. (p. 138)

The question then becomes how can critical thinking development accurately be assessed? Researchers have utilized numerous instruments over the years in an attempt to explain the varying aspects of critical thinking. The Watson-Glaser Critical Thinking Appraisal (WGCTA) (Watson & Glaser, 1980), the Cornell Critical Thinking Test (CCTT) (Ennis, Millman, & Tomko, 1985), and the California Critical Thinking Skills Test (CCTST) (Facione, 1992) are among the most widely known means of assessing student acquisition of critical thinking skills (Jacobs, 1995; Fawkes, 2001). Although widely known and utilized, each of the aforementioned critical thinking assessments are limited by their format in that it is difficult for any multiple choice exam to accurately assess the range of basic critical thinking skills (Fawkes, O'Meara, Webber, & Flage, 2005). This study seeks to make a significant contribution to the literature by exploring critical thinking development and assessment in an undergraduate agricultural education and studies program through the utilization of an updated, short answer format critical thinking assessment tool, the Critical Thinking Assessment Test (CAT).

Statement of the Problem

Although possessing critical thinking abilities as a college graduate is a desired outcome of higher education universities (AACU, 2004, 2007, 2010), limited research is available to examine critical thinking abilities of students in colleges of agriculture (Rudd et al., 2000). There is a need to explore higher education students' current critical thinking abilities and factors influencing the development of these abilities.

Objectives of the Study

The purpose of this study was to describe the current critical thinking abilities of undergraduate agriculture education and studies students and to explore how entry pathway and enrollment in a capstone course affected these abilities. The following research objectives guided this study:

1. Establish a departmental benchmark for critical thinking abilities of undergraduate agricultural education and studies students.
2. Determine if entry pathway, direct from high school admittance versus transfer from community college admittance, had an effect on the critical thinking abilities of agricultural education and studies students.
3. Explore the impact a semester-long capstone farm management course had on the development of undergraduate agricultural education and studies students' critical thinking abilities.

Significance of the Study

The results from this study create a better understanding of the role a program of study can have on students' abilities to critically analyze and evaluate complex scenarios. Through exploring this area, instructors and administrators have the opportunity to formulate a more holistic framework around critical thinking. This more holistic framework provides a foundation for student gains in critical thinking for which many institutions strive. Additionally, the results from this study provide a departmental baseline for evaluating the critical thinking and problem-solving outcome outlined by the CALS.

Definition of Terms

Contextual definitions of key terms used in this study are as follows.

1. 21st Century Skills – complex thinking skills required for students to communicate, collaborate, and problem solve on a global scale (Saavedra & Opfer, 2012).
2. Capstone Course – a planned learning experience that requires students to synthesize previously learned subject matter content and to integrate new information into their knowledge base to solve simulated or real world problems (Crunkilton, Cepica, & Fluker, 1997).
3. Critical Thinking – "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 et al., 2000, p. 5).
4. Critical Thinking Assessment Test (CAT) – a fifteen-question, short answer assessment tool designed to promote the improvement of critical thinking and problem solving skills (Center for Assessment and Improvement of Learning [CAIL], 2012).
5. Critical Thinking Disposition – an individual's internal motivation to use critical thinking skills (Pascarella & Terenzini, 2005).
6. Entry Pathway – describes the path a secondary level student takes to become a higher education student. This is either through progressing from high school

directly to a four-year institution or by progressing from high school to a two-year institution and transferring to a four-year institution.

Dissertation Organization

This dissertation is divided into seven chapters. Chapter one provides a general introduction. Chapter two summarizes the literature surrounding the development, assessment, and importance of critical thinking abilities. Chapter three outlines the research methods utilized. Chapter four provides a research manuscript establishing a departmental benchmark for the critical thinking abilities of undergraduate agricultural education and studies students. Chapter five provides a research manuscript that reports the influence of collegiate entry pathway on critical thinking abilities. Chapter six presents a research manuscript examining the relationship between enrollment in a single course and the development of critical thinking abilities. Chapter seven includes the conclusions, implications and recommendations.

CHAPTER II. LITERATURE REVIEW

The purpose of this study was to describe current critical thinking abilities of undergraduate agriculture education and studies students, and to explore how entry pathway and enrollment in a capstone course affect these abilities. The following research objectives guide this study:

1. Establish a departmental benchmark for critical thinking abilities of undergraduate agricultural education and studies students.
2. Determine if entry pathway, direct from high school admittance versus transfer from community college admittance, had an effect on the critical thinking abilities of agricultural education and studies students.
3. Explore the impact a semester-long capstone farm management course had on the development of undergraduate agricultural education and studies students' critical thinking abilities.

This chapter will begin by identifying various, interconnected critical thinking components and then transition to exploring a developmental model which outlines philosophical foundations central to the development of individuals' critical thinking abilities. Higher education's ability to prepare students with the changing skill sets required for success in today's world will then be discussed. Finally, the conceptual and theoretical frameworks that have not only provided direction for this dissertation, but for critical thinking teaching strategies as well, will be explored.

Defining Critical Thinking

Critical thinking must be defined in a way that allows for generalizability across disciplines, is informed by empirical data, and is situated in a developmental framework

(Kuhn, 1999). At its very basic 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) and perceived as "an abstract, generalizable, learned, rational process, synonymous with decision making" (Gordon, 2000, p. 346). Within the context of agricultural 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 is defined in numerous ways, but 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 thinking can be further broken into the following competencies (Possin, 2008):

> (a) identifying reasons or arguments, (b) dissecting arguments into premises, conclusions, and sub conclusions, (c) taxonomizing arguments as deductive or inductive, (d) assessing the cogency of arguments, (e) identifying formal and informal fallacies, (f) critically reviewing definitions and analyzing concepts, and (g) assembling these competencies so as to select and argue for positions on a diversity of issues and critically review competing positions and their arguments, all in a cogent and intellectually honest manner (p. 205).

Critical thinkers possess a set of affective dispositions that enable them to address situations requiring higher-ordered thinking (Facione, 1990). Although a person can have the cognitive skills to think critically, they are more effective thinkers if they exhibit these affective dispositions (Rudd, 2007). The affective dispositions identified by Facione (1990) include:

> (a) inquisitiveness with regard to a wide range of issues, (b) concern to become and remain generally well-informed, (c) alertness to opportunities to use critical thinking, (d) trust in the processes of reasoned inquiry, (e) self-confidence in one's own ability to reason, (f) open-mindedness regarding divergent world views, (g) flexibility in considering alternatives and opinions, (h) understanding of the opinions of other people, (i) fair-mindedness in appraising reasoning, (j) honesty in facing one's own biases, prejudices, stereotypes, egocentric or sociocentric tendencies, (k) prudence in suspending, making or altering judgments, and (l) willingness to reconsider and revise views where honest reflection suggests that change is warranted (p. 13).

Specific to cognitive skills, analysis, evaluation, inference, deductive reasoning, and inductive reasoning possess substantial influence on critical thinking skills (Facione, 2011). Although Bloom’s (1956) taxonomy was revised by Anderson et al. (2001), Duron et al. (2006) recognized some of the cognitive skills associated with critical thinking development aligned with Bloom’s (1956) original taxonomy. Bloom (1956) identified the six hierarchical cognitive domains as *Knowledge, Comprehension, Application, Analysis, Synthesis,* and *Evaluation*. 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).

It is important to keep in mind critical thinking is not simply a random compilation of components (Willsen, 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 (Willsen, 1995). Thus, an examination of Kuhn's (1999) developmental model of critical thinking addressing the issue of generalizability of gains beyond immediate instructional contexts is warranted.

A Developmental Model of Critical Thinking

The focus of Kuhn's (1999) Developmental Model of Critical Thinking is meta-knowing, knowing about one's own as well as others' knowing, and is further divided into three categories identified as metacognitive, metastrategic, and epistemological understanding. Individual's epistemological commitments, metacognitive processing of behavior, and critical thinking are integral components of controlling learning (Tsai, 2001). Metacognition operates on an individual's base of declarative knowledge (know that), while metastrategic knowing operates on an individual's procedural knowledge (knowing how) (Kuhn, 1999). Epistemological knowing focuses on general philosophical aspects and personal aspects. Although the three categories will be further examined individually, it is important to acknowledge the aspects of each appear throughout the broad focus of meta-knowing (Kuhn, 1999).

Metacognitive Understanding

Metacognitive understanding is vital to critical thinking because of its focus on developing reflection of how we know what we know and why it is justified (Kuhn, 1999), as well as its ability to affect “acquisition, comprehension, retention, and application of what is learned” (Hartman, 1998, p.1). Metacognitive knowing begins around the age of three years, when youth realize assertions are representative of other’s beliefs (Kuhn, 1999). This group is limited in its critical thinking applications if beliefs are seen as assertions known by the individual as certainties (Kuhn, 1999). However, if assertions can be seen as belief states open to evaluation, critical thinking can emerge (Kuhn, 1999). To evaluate these belief states, individuals must develop the metacognitive skill of information organization where previously acquired knowledge can be systematically merged with newly identified information (Tsai, 2001). The level of critical thinking associated with the evaluation of belief states will be minimal, though, if the evaluations can only be deemed true or false (Kuhn, 1999).

Metastrategic Knowing

Metastrategic knowing asserts significant thinking is absent if individuals view the world as a reflection of fact more than a reflection of perception, and it has further been shown to aid critical thinking abilities through the development of strategies that allow for consistent models of evaluations across contexts (Kuhn, 1999). Metastrategic knowledge can best be defined as “general knowledge about cognitive procedures that constitute higher-order thinking skills and strategies” (Zohar & Peled, 2008, p. 338). Metastrategic knowing emerges when individuals continually shift the frequency of usage of strategies with diminished usage and eventual deletion of less adequate strategies (Kuhn, 1999). Individuals additionally combine difficult evaluation strategies with simpler strategies to optimize performance (Brown, 2008). Thus, the primary metastrategic task becomes strategy selection (Kuhn, 1999).

Epistemological Understanding

Epistemological understanding is the foundation of critical thinking, since it encourages individuals to understand the reason for thinking so they can truly engage it (Kuhn, 1999). Further, epistemological understanding heavily influences an individual's decision making process in regards to what to believe and what to do (Tsai, 2001). Four stages of epistemological knowing are evident: realist, absolutist, multiplist, and evaluative (Figure 2.1). Realists view assertions as copies that represent external reality, where reality is directly knowable and knowledge is certain (Kuhn, 1999). Therefore, realists see critical thinking as unnecessary (Kuhn, 1999).

The absolutist stance does not attribute the construction of knowledge to the individual (Kuhn, 1999). Rather, knowledge remains in the external world, awaiting discovery (Kuhn, 1999). Absolutists rely on a concept of truth, where belief states can be viewed as right or wrong in relation to a truth and authority figures are expected to convey said truth to the learner (Hofer & Pintrich, 1997). Evidence of elementary critical thinking is present in absolutism, since it recognizes claims can be disputed, but this dispute can only be resolved by a declaration of the assertion being true or false, limiting critical thinking influence (Kuhn, 1999).

Most individuals progress to multiplism during adolescence stages (Kuhn, 1999). This multiplist epistemology asserts if even experts cannot be counted on to provide answers, the concept of certainty is a fallacy (Kuhn, 1999). Thus, multiplists are inclined to believe each person has a right to an opinion and all opinions are equally valid (Hofer & Pintrich, 1997). The critical thinking skills of multiplists are often lower than absolutists since absolutists are willing to evaluate assertions against a truth instead of simply taking them at face value as multiplists do (Kuhn, 1999).

Level	Assertions	Reality	Knowledge	Critical Thinking
Realist	Assertions are copies that represent an external reality.	Reality is directly knowable.	Knowledge comes from an external source and is certain.	Critical thinking is unnecessary.
Absolutist	Assertions are facts that are correct or incorrect in their representation of reality, (possibility of false belief).	Reality is directly knowable.	Knowledge comes from an external source and is certain.	Critical thinking is a vehicle for comparing assertions to reality and determining their truth or falsehood.
Multiplist	Assertions are opinions freely chosen by and accountable only to their owners.	Reality is not directly knowable.	Knowledge is generated by human minds and is uncertain.	Critical thinking is irrelevant.
Evaluative	Assertions are judgments that can be evaluated and compared according to criteria of argument and evidence.	Reality is not directly knowable.	Knowledge is generated by human minds and is uncertain.	Critical thinking is valued as a vehicle that promotes sound assertions and enhances understanding.

Figure 2.1. A developmental model of critical thinking. From Kuhn, 1999, p. 23. Reprinted with permission.

Evaluative epistemology recognizes this fallacy of opinion equality and asserts all opinions are not equal (Kuhn, 1999). “Evaluative epistemologists deny the possibility of certain knowledge and recognize expertise and view themselves as less certain than experts” (Hofer & Pintrich, 1997, p. 104). Very few individuals reach the evaluative level and only the evalutist can be successful in integrating and coordinating subjective and objective knowledge attainment and acquisition (Kuhn, 1999). The absolutists view knowledge acquisition in an objective manner, where assertions are reflections of the external world and knowable with certainty. Multiplists are subjective to the extent of a downfall, since this view overpowers any objective stance that could allow for a comparison or evaluation of assertions (Kuhn, 1999).

21st Century Educational Environment

Kuhn's (1999) developmental model of critical thinking was intended to serve as a bridge connecting research to educational practice. Similar to the focus of 21st century learning, Kuhn's (1999) developmental model of critical thinking addressed the issue of generalizability of gains beyond immediate instructional contexts. This is an ever-changing world, where technology seemingly provides endless answers. With smartphones and tablets, the Internet is widely accessible at almost any time or location. This new age of unlimited information accessibility has triggered a recent change among students (Ebersole, 2000). It is no longer a matter of locating desired information. It is now an issue of validating the reliability of the information found. The skills required to be successful in this new age of excess and often unreliable information are known as 21st century skills and include: (1) critical thinking and problem solving, (2) collaboration and leadership, (3) agility and adaptability, (4) intuitiveness and entrepreneurialism, (5) effective oral and written communications, (6) accessing and analyzing information, and (7) curiosity and imagination (The Partnership for 21st Century Skills [P21], 2009; Wagner, 2008).

The necessity to adapt to the ever-changing personal, social, and professional demands of the 21st century is a platform for establishing critical thinking as the very essence of education (Paul, 1995). The individuals and organizations at the forefront of higher education reform recognize an apparent shift from contextual memorization and rote regurgitation of facts and offer widespread changes reflecting an emphasis on critical thinking, problem solving, and communications (Paul, 1995; Rhodes, Miller, & Edgar, 2012; Willsen, 1995; Wright, 1992). For example, The Association of American Colleges and Universities (AACU) (2004, 2007, 2010) recognized critical thinking and problem solving among a set of outcomes valued by universities. Further, P21 developed a framework to assist instructors with curriculum and assessment development, which nested critical thinking, problem solving, and communications among the top 21st century student outcomes (P21, 2009).

Higher Education Preparedness

Critical thinking is a fundamental, overarching outcome of higher education meant to teach students how to improve their thinking (P21, 2009; Willsen, 1995). Faculty members perceive the responsibility of helping students develop higher-order thinking skills among higher education's primary teaching roles (Cross, 1993). Well-prepared higher education faculty possess the ability to influence students' critical thinking dispositions (Burbach, Matkin, Quinn, & Searle, 2012) and overall critical thinking abilities (Felder & Brent, 2010) in as little as one semester. Thus, higher education faculty members would seemingly need to acquire and maintain a comprehensive understanding of critical thinking. Yet, there is an apparent general lack of critical thinking knowledge among teaching appointment faculty (Stedman & Adams, 2012), as well as little evidence demonstrating critical thinking development occurs in the college classroom (Tsui, 2001).

Some faculty members accurately conceptualize critical thinking as putting it all together through seeking information, reflection, assigning meaning, solving problems, and applying information (Twibell, Ryan, & Hermiz, 2005). Initial confusion surrounding critical thinking includes the misguided belief students' abilities to explain concepts in their own words equate 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).

The lack of congruency among faculty in identifying critical thinking components is an issue. Faculty should work together to experiment and share promising alternatives for infusing critical thinking into coursework (Tsui, 2001). This general lack of critical thinking knowledge among faculty along with the lack of a critical thinking presence in collegiate classrooms supports Paul's (1995) assertion of the misalignment between the skills required to be successful in the 21st century, such as critical thinking, and those being taught in modern education.

Instructors are often unaware of the most effective strategies of teaching at higher levels (Stedman & Adams, 2012). In fact, Paul (1995) suggested most instructors think in lower order ways because they simply lack the basic understanding of what constitutes higher ordered thinking. Paul's (1995) notion possesses higher education implications, since for students to express critical thinking skills, instructors must first possess and develop these same skills (Yang, 2012). Further, it is believed critical thinking can only be taught by instructors who possess an in-depth knowledge of critical thinking (Choy & Cheah, 2009). To attain an in-depth understanding of critical thinking, instructors must: "(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).

Critical Thinking Assessment

Assessment is a means of enhancing instructional quality as well as student learning and performance (Duron et al., 2006). According to Jacobs (1995) and Fawkes (2001), the most widely known means of assessing student acquisition of critical thinking skills are the Watson-Glaser Critical Thinking Appraisal (WGCTA) (Watson & Glaser, 1980), the Cornell Critical Thinking Test (CCTT) (Ennis, Millman, & Tomko, 1985), and the California Critical Thinking Skills Test (CCTST) (Facione, 1992). Although widely known and utilized, each of the aforementioned critical thinking assessments are limited by their format; it is difficult for any multiple choice exam to accurately assess critical thinking skills (Fawkes, O'Meara, Webber, & Flage, 2005). The following three sections will briefly outline each of the aforementioned critical thinking assessments. Then, an introduction of the assessment instrument selected for this study, The Critical Thinking Assessment Test (CAT), is presented, as well as a justification for its use over the other assessment measures.

WGCTA

The WGCTA is a 30-60 minute, multiple-choice formatted test designed to measure various interdependent aspects of critical thinking through different constructs identified as inferences, recognition of assumptions, deduction, interpretation, and evaluation of arguments (Hassan & Madhum, 2007). The WGCTA has been utilized to assess critical thinking skills of students ranging from high school freshmen through university graduate students and provides reference norms (Hassan & Madhum, 2007). The WGCTA also possesses adequate internal consistency and test reliability over time and between alternate forms (Rust, 2002). Further, the WGCTA demonstrates adequate face, content, criterion, and construct validity (Rust, 2002).

CCTT

In an attempt to more accurately assess critical thinking competencies associated with the effectiveness of curricular and instructional innovativeness, the CCTT was the result of a long-term research program by its creators (Jacobs, 1995). Intended audiences for the CCTT include elementary through junior high students (i.e., Form X), as well as high school and college students (i.e., Form Z) (Jacobs, 1995). This multiple choice question test provides a single score based on measurable items in induction, deduction, evaluation, observation, credibility of statements, identification of assumptions, and the ability to discern meaning (Jacobs, 1995). Due to the lack of availability of equivalent forms and technical characteristic data, numerous critiques recommend the WGCTA over the CCTT (Jacobs, 1995).

CCTST

The CCTST is an “objectively scored standardized instrument that addresses the cognitive skills dimension of critical thinking” (Jacobs, 1995, p. 90). Thirty-four multiple-choice questions were selected from a pool of 200 after revisions and item analyses conducted in a Delphi study (Jacobs, 1995). These thirty-four items can be scored to yield sub-scores representing analytic, evaluation, and inferential abilities or 30 of the items can be scored to yield deductive and inductive reasoning capabilities (Jacobs, 1995). The CCTST has been shown to present false negative evaluations for nine of the

34 questions (Fawkes et al., 2005). However, the remainder of the CCTST is reliable in respect to content and the defective nine questions can easily be removed during test delivery (Fawkes et al., 2005).

CAT

The CAT is a short-answer, fifteen-question test created to assess and improve critical thinking and real-world problem solving skills (Center for Assessment and Improvement of Learning [CAIL], 2012). The CAT instrument is designed to evaluate the effects of college education, a program of study, a specific course, and informal learning experiences (CAIL, 2012). Developed by an interdisciplinary team of faculty, specific skill areas assessed by the CAT instrument include: (1) evaluating information and other points of view, (2) creative thinking, (3) learning and problem solving, and (4) communication. The CAT instrument was utilized to assess critical thinking abilities in this study primarily because its short-answer format combats the argument it is difficult for any multiple-choice exam to accurately assess the range of basic critical thinking skills (Fawkes et al., 2005).

Developing Critical Thinking Abilities

Since critical thinking abilities are a result of critical thinking dispositions and a set of facilitating factors, which include demographics, academic performance, and experience and training (Ricketts & Rudd, 2005), the following sections will address each facilitating factor independently. Before progressing further, a visual representation of the critical thinking literature discussed thus far is presented in Figure 2.2 for summarization purposes. The visual representation displays common components of critical thinking definitions, division of Bloom's (1956) Taxonomy, critical thinking instructional approaches, and common critical thinking assessment instruments.

Demographic Characteristics Associated with Critical Thinking

When researching broad teaching and learning components, gender is continually identified as a key variable (Bers, McGowen, & Rubin, 1996). However, little consistency surrounds the role gender possesses in critical thinking development. Some research suggests the rate of critical thinking development among males majoring in social and mathematical science is higher than the rate for females (King, Wood, & Mines, 1990), while other research suggests females enrolled in entry level mathematics, English, natural science, and psychology courses possess statistically significant higher critical thinking assessment scores (Bers et al., 1996). Yet, gender has also been shown to play only a limited role in determining critical thinking skills of first-year freshmen (Jacobs, 1995) and to have no significant influence in any critical thinking models within an introductory accounting course (Brahmasrene & Whitten, 2011).

Slightly more clarity is evident when age is associated with critical thinking skills. Older students, typically over age 25, display statistically significant higher critical thinking dispositions than younger students enrolled in entry level mathematics, English, natural science, and psychology courses (Bers et al., 1996). Although not as strong as the relationships found in other research (Bers et al., 1996), Jacobs (1995) claims age as a second predictor of critical thinking skills behind SAT verbal scores among first-year freshmen.

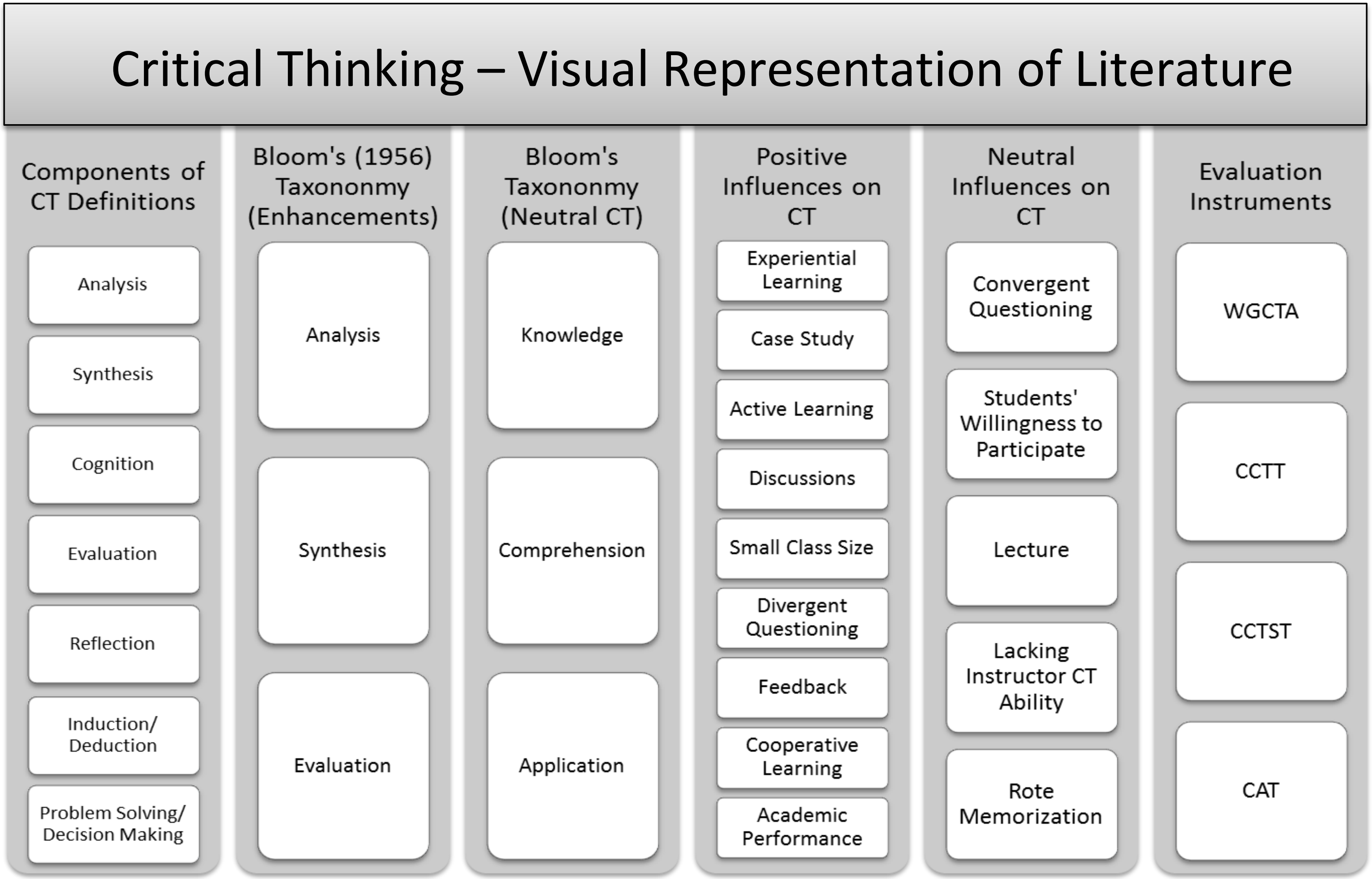

Figure 2.2. Visual representation of critical thinking literature

Similar discrepancies among gender and age are evident when reviewing research within Agricultural Education. Ricketts and Rudd (2005) suggested gender may account for some of the variance in a student's critical thinking skills. Rudd et al. (2000) further confirmed gender differences by reporting females possessed higher critical thinking dispositions than males. However, other research within Agricultural Education reported no statistical differences in critical thinking dispositions or skills, according to gender (Brisdorf-Rhoades, Ricketts, Irani, Lundy, & Telg, 2005; Burbach et al., 2012; Friedel, Irani, Rhoades, Fuhrman, & Gallo, 2008; Friedel, Irani, Rudd et al., 2008). Slightly different evidence exists when age is associated with critical thinking skills among agricultural education students. Some research suggested no significant connections existed between students' ages and critical thinking dispositions (Burbach et al., 2012; Rudd et al., 2000). Yet, other research has connected students' ages and critical thinking ability (Ricketts & Rudd, 2005).

Academic Characteristics Associated with Critical Thinking

Academic characteristics are more reliable than demographic characteristics to explain variations among critical thinking skills. 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; Ricketts & Rudd, 2005). A deeper understanding of the relationship between academic characteristics and critical thinking skills has been found through exploring SAT associations. Highly significant *t*-values ($p < 0.01$) 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 have been identified as the best predictors of critical thinking abilities when utilizing SAT scores (verbal and mathematical), age, and gender as predictor variables in regression analyses (Jacobs, 1995).

Experience and Training

Experience and training are the remaining facilitating factors determining critical thinking ability (Ricketts & Rudd, 2005). Traditionally, teaching critical thinking has been primarily reflective of two perspectives. The first perspective suggests critical thinking be addressed within the context of subject matter instruction, while the second suggests it be addressed as a general entity (Kuhn, 1999). Burbach et al. (2012) suggested combining the two perspectives, where instructors should integrate critical thinking pedagogies into courses and overtly teach critical thinking skills and dispositions. Case studies (Popil, 2011), student-centered discussions (Tsui, 2002; Yang, 2012), and divergent questioning (Duron et al., 2006) have all demonstrated an ability to increase students' critical thinking skills. Further, since writing is a systematic process that forces students to arrange their thoughts and make them accessible to others (Willsen, 1995), writing and re-writing aid in the development of critical thinking skills (Tsui, 2002).

Perhaps one of the most common instructional techniques demonstrated to positively affect students' critical thinking skills is active learning (Duron et al., 2006; Popil, 2011; Tsui, 2002; Yang, 2012; Youngblood & Beitz, 2001). Similar to student centered learning, active learning environments place the instructor as a facilitator of learning, allowing for an emphasis on learning and student accountability (Biggs, 1999). Students who are taught using active learning 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 techniques (Lee & Jabot, 2011), student led debates (Roy, 2012), and even the one-minute paper, where students state the main, most clear, or muddiest point in the lecture (Adrian, 2010).

Model to Move Students Toward Critical Thinking

In an attempt to address the higher education issue of integrating active learning activities into holistic pedagogical approaches to facilitate critical thinking, Duron et al. (2006) created the *5-Step Model to Move Students Toward Critical Thinking* (Figure 2.3). 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.

Step one. The *5-Step Model to Move Students Toward Critical Thinking* begins with determining learning objectives that define expected behaviors upon course completion. Attention to the underlying role and purpose of the course to the overall program of study should be made in the developmental stages of step one. The model reiterates the importance of creating learning objectives, activities, and assessments that keep students in the upper levels of Bloom's (1956) taxonomy, since these are the levels where critical thinking occurs. Specific activities aligning with these upper taxonomy levels help students develop their ability to "categorize, differentiate, combine, construct, create, assess, criticize, predict, and evaluate" (pp. 161-162) concepts or ideas. The final product of step one is the development of a lesson plan targeting a specific behavior, allowing activities for practice of the desired behavior, and concluding with evidence of the desired behavior's understanding (Duron et al., 2006).

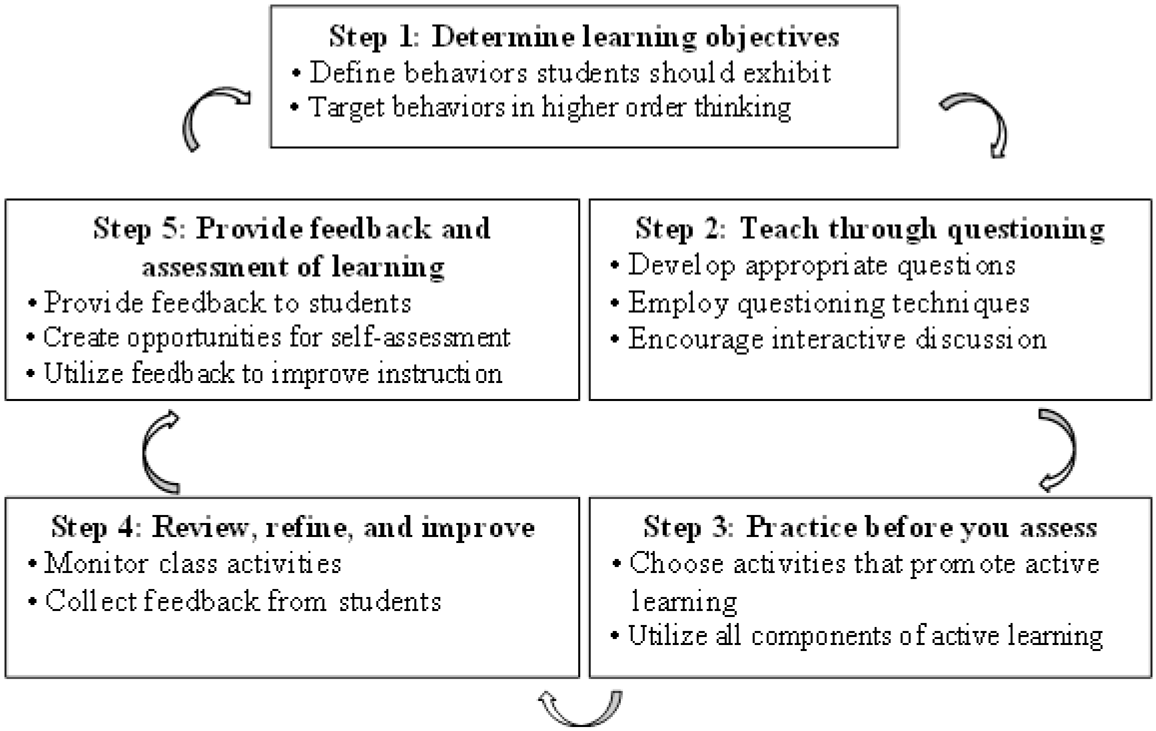

Figure 2.3. The 5-Step Model to Move Students Toward Critical Thinking (Duron et al., 2006, p. 161).

Step two. Next, the model focuses on teaching through questioning. Questioning is an effective means of building critical thinking skills because it stimulates interaction between instructor and student, which results in the student defending his/her stance (Duron et al., 2006). For clarity, it is recommended to categorize questioning techniques into two broad categories of convergent or divergent, where convergent questioning refers to seeking a specific answer and divergent questioning accepts a wide range of correct answers (Duron et al., 2006). Referring again to Bloom's (1956) taxonomy, convergent questioning applies to the lower levels and divergent questioning applies to the higher levels. Therefore, instructors should strive to master divergent questioning techniques, if the desired outcome is to foster critical thinking. Deliberate instructor preparation is required to create effective questions (Duron et al., 2006).

Step three. The role of active learning and the importance of practicing before assessing are stressed throughout the third step. Duron et al. (2006) preface step three by acknowledging the recent shift in higher education to reflect an environment more conducive to learner-centered education, specifically active learning. In active learning environments, instructors act as facilitators of learning, and an emphasis on deep learning and student accountability is evident (Biggs, 1999). Representative of Bloom's (1956) *Synthesis* level, activities representing active learning would resemble students gathering information and ideas from a variety of sources both inside and outside the classroom, and then incorporating the newly attained information into an actively involved experience (Fink, 2003). The exercise should then conclude with an in-depth reflective dialog assignment, such as a paper, portfolio, or journal to allow students the opportunity to actively reflect on the meaning of the learning exercise (Fink, 2003).

Step four. The next step of the model involves reviewing, refining, and improving. Instructors should continually strive to refine their courses to ensure critical thinking remains a focal point of instructional techniques (Duron et al., 2006). Duron et al. recommended higher education instructors utilize a variation of a diary or journal to record and monitor classroom activities, student participation, and assessments of student success. This information could then be utilized to revise and update instructional activities. Duron et al. (2006) also recognized the importance of student feedback in this step, and referred to Angelo and Cross (1993) for recommendations regarding the collection of vital student information required to adjust learning techniques. Angelo and Cross suggested incorporating techniques similar to the two-minute paper or chain note, where students can self-identify the areas of the lesson most and least understood.

Instructors can then use this information to refine and improve instructional techniques. Ultimately, Duron et al. (2006) identified step four as an opportunity for students to recognize the consideration the instructor places on continually improving learning.

Step five. The final step of the *5-Step Model to Move Students Toward Critical Thinking*, similar to Bloom's (1956) final *Evaluation* level, is to provide feedback and assessment of learning. Duron et al. (2006) assert feedback and assessment are more effectively utilized for the purpose of enhancing the quality of instruction, as well as student learning and performance, as opposed to a mechanism for providing a numerical grade. This approach allows students the opportunity to learn how to assess their own performance. Adequate time should be spent to determine precisely what is expected from students through identifying a set of criteria or standards through which performance will be evaluated (Duron et al., 2006). The final step of the model acknowledges the importance of assessment to the 5-step model. The information collected from each step of the model, such as completed objectives, effectiveness of learning activities, and quality of feedback on standards, should be incorporated into course improvement strategies, as well as contribute to outcomes-based assessment efforts (Duron et al., 2006).

Experiential Learning

Duron et al.'s (2006) aforementioned model moves students toward critical thinking through the intentional integration of active learning techniques. Categorized as active learning, experiential learning, pertinent to this study, provides students with an opportunity to make substantial gains in critical thinking (Duron et al., 2006). Experiential learning can be defined as "the process whereby knowledge is created through the transformation of experience" (Kolb, 1984, p. 41). Similar to the complex nature of critical thinking, Steinaker and Bell (2002) asserted an experience cannot be understood by fragmentation. Rather, for complete learning to occur, all levels and steps of an experiential learning process must occur (Dewey, 1938; Joplin, 1981; Kolb, 1984; Roberts, 2006; Steinaker & Bell, 2002; Zull, 2002).

All learning is experiential (Dewey, 1938; Joplin, 1981), but all experiences are not educational (Dewey, 1938). "Learning is not a discrete process with a beginning and end, but rather on ongoing process" (Roberts, 2006, p. 22) and is reflected through the cyclical nature of the experiential leaning models of Dewey (1938), Joplin (1981), and Kolb (1984) (Roberts, 2006). Human experiences are inseparable from one another and are the sum total of previous activities (Steinaker & Bell, 2002).

Kolb's (1984) model of experiential learning is widely accepted within the agricultural education learning community (Osborne, 1994) and compliments fundamental critical thinking foundations as well. Kolb's (1984) experiential learning model (Figure 2.4) depicts learning as a series of transitions between concrete experiences, reflective observations, abstract conceptualizations, and active experimentation. The model can be further grouped into two dialectically-related modes of grasping experience—concrete experiences and abstract conceptualizations—and two dialectically-related modes of transforming experience—reflective observations and abstract experimentation (Kolb & Kolb, 2009).

Similar to critical thinking's metacognitive understanding, where individuals must openly remove biases to reflect upon how they know what they know and why it is justified (Kuhn, 1999), the concrete experience mode of Kolb's (1984) experiential learning model requires learners to approach new experiences openly, without biases, and fully involve themselves in the experience. The concrete experience mode is dynamic. People continually move from the concrete to the abstract and return to the concrete (Dale, 1946). Agricultural education strives to intentionally provide concrete learning experiences, but oftentimes fails to place these learning experiences in the context of experiential learning (Osborne, 1994; Shoulders & Myers, 2013).

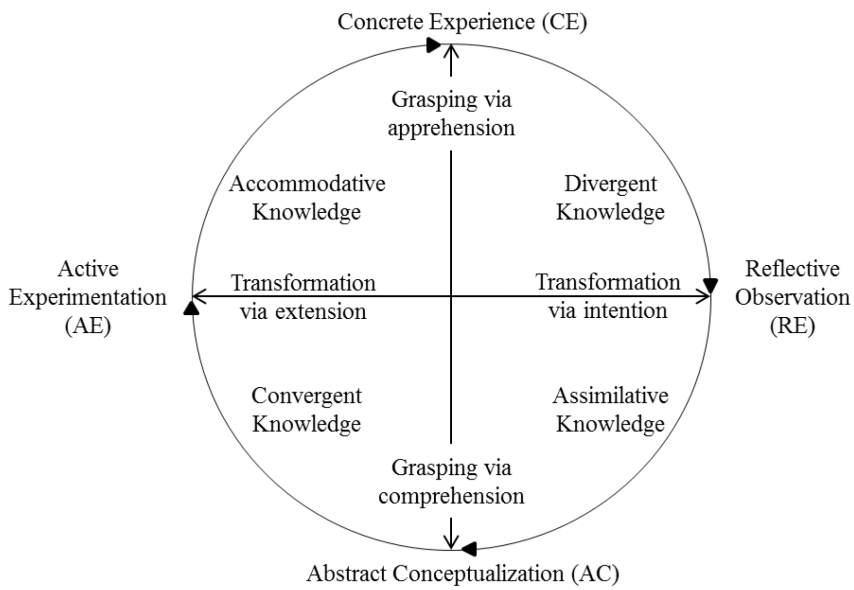

Figure 2.4. Model of Experiential Learning Process (Kolb, 1984).

The next mode requires learners to utilize multiple perspectives to engage in reflective observations (Kolb, 1984). Reflection is a key element in critical thinking (Facione, 1990; Kuhn, 1999; Twibell et al., 2005) and in experiential learning, since it transforms experiences into new knowledge (Osborne, 1994). However, reflection is often skipped entirely in an attempt to shortcut directly to an idea or action (Zull, 2002). In the abstract conceptualization mode, logically sound theories can then be formed through created concepts grounded in observation (Kolb, 1984).

Similar to critical thinking's metastrategic understanding, where newly developed strategies are utilized to make evaluations across contexts (Kuhn, 1999), the final mode of Kolb's (1984) experiential learning model, active experimentation, allows students to utilize the newly created theories to solve problems and make decisions. Agricultural instructors rarely provide opportunities for knowledge transformation because they simply do not reach this mode often enough (Osborne, 1994; Shoulders & Myers, 2013).

Kolb's (1984) experiential learning model further depicts four "elementary forms of knowledge that later become the building blocks for developing higher levels of knowing [critical thinking]" (p. 42). Kolb (1984) describes them as follows:

> Experience grasped through apprehension and transformed through intension results in what will be called divergent knowledge. Experience grasped through comprehension and transformed through intension results in assimilative knowledge. When experience is grasped through comprehension and transformed through extension, the result in convergent knowledge. And finally, when experience is grasped by apprehension and transformed by extension, accommodative knowledge is the result (p. 42).

Kolb's (1984) experiential learning model is not without critiques, one which possesses implications for critical thinking understanding. Rogers (1996) asserts "learning includes goals, purposes, intentions, choice and decision-making, and it is not at all clear where these elements fit into the learning cycle" (p. 108). This critique is of concern to critical thinking understanding as purposeful actions/intentions (Paul, 1995; Popil, 2011; Rudd et al., 2000) and decision-making (Gordon, 2000) are common elements in fundamental critical thinking definitions. However, critical thinking's presence in experiential learning should not be discounted, since critical thinking, similar to experiences, should be viewed as an integrated working system and not simply as a fragmentation of components (Steinaker & Bell, 2002; Willsen, 1995).

Practical Inquiry

Practical inquiry allows for additional critical thinking integration by creating additional opportunities for imagination integration as the most effective applications of critical and creative thinking occur when these two processes are highly integrated (Bleedorn, 1993). Practical inquiry mirrors a foundation in experiential learning, but allows for imagination and reflection to feed into experience and practice (Dewey, 1933). The Practical Inquiry Model (Garrison, Anderson, & Archer, 2000) (Figure 2.5) possesses an intentional resemblance to Kolb’s (1984) experiential learning model and serves as a framework for the operationalization of cognitive presence grounded in critical thinking. Similar to Kuhn’s (1999) recommendation of utilizing pedagogical approaches that allow students to foster an understanding of the overall thinking process, the Practical Inquiry Model asserts the acquisition of critical thinking skills would be greatly assisted by an understanding of the thought process (Garrison, Anderson, & Archer, 2001).

The first dimension of the model reflects a perception-conception relationship, where a continuum exits between action and deliberation, and a transition is evident between the concrete and abstract worlds (Garrison et al., 2000). The next dimension identifies the four essential phases in describing and understanding cognitive presence in an educational context as triggering event, exploration, integration, and resolution (Garrison et al., 2000). The first phase, triggering event, introduces an issue that has emerged from experience and is often explicitly communicated via the instructor (Garrison et al., 2000). This initial phase provides individuals an entry-level opportunity to begin to explore a critical thinking epistemological understanding, since it encourages individuals to explore the reason for thinking so they can truly engage it (Kuhn, 1999).

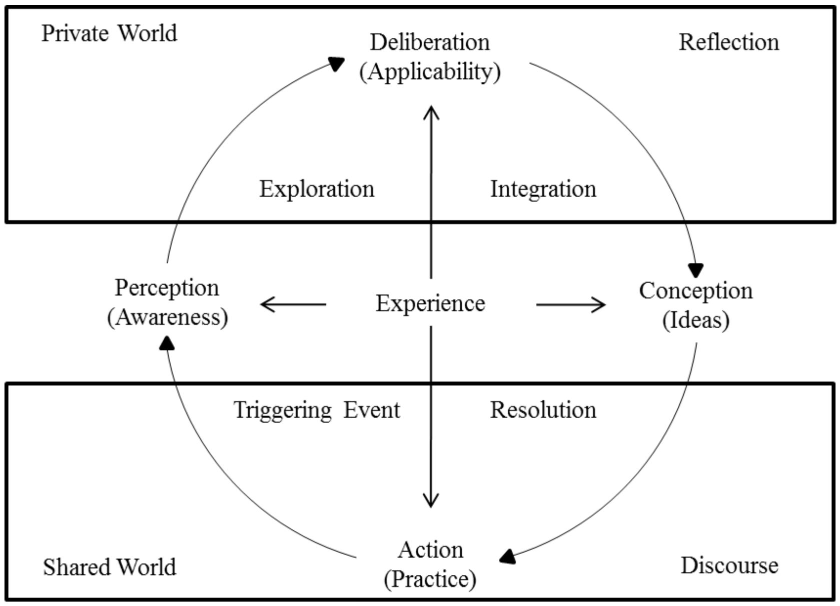

Figure 2.5. Practical Inquiry Model. From Garrison, Anderson, & Archer, 1999, p. 99. Reprinted with permission.

The exploration phase allows participants to shift between individual reflection and social exploration, while comprehending and selecting relevant information (Garrison et al., 2000). Critical thinking is present throughout this phase, since it allows students to analyze and evaluate information (Duron et al. 2006) and concepts (Possin, 2008), and to address questions with incomplete information (Rudd et al., 2000). In the next phase, integration, individuals construct meaning and assess applicability of ideas generated in the exploratory phase (Garrison et al., 2001), much like the critical thinking skill of deducing conclusions from information (Pascarella & Terenzini, 1991). The final phase, resolution, requires a proposed solution to the problem and often presents opportunities to apply newly created knowledge (Garrison et al., 2000).

As the model possesses a pragmatic focus, it considers education to be reflective of lived experiences and suggests learning within an educational context should be applicable to real-world situations (Garrison et al., 2001). Thus, the Practical Inquiry Model provides a segue for further linking experiential learning models to educational environments emulating real-world scenarios, such as capstone courses.

Capstone Courses

Experiential learning models provide solid, theoretical foundations for capstone courses (Andreasen, 2004). Therefore, capstone courses would seemingly be ideal environments for exploring critical thinking skills. A capstone course is an in-depth study, grounded in a particular discipline that goes beyond the limitations of the current curriculum (Wagenaar, 1993). Capstone courses allow students the opportunity to make significant linkages between the current curriculum and industry standards (Fairchild & Taylor, 2000). More specifically, a capstone learning experience is one that cultivates problem-solving skills, utilizes a multi-disciplinary approach, builds teamwork and interpersonal skills, develops information sources, and requires written and oral reports (Kranz, 1991). Specific to capstone courses in colleges of agriculture, Crunkilton, Cepica, and Fluker (1997) identified five required learning activities of capstone courses as project and/or case studies, small group work, issues analysis, oral communication, and industry involvement. Crunkilton et al. also identified six expected educational outcomes of capstone courses as problem solving, decision-making, critical thinking, collaborative/professional relationships, oral communications, and written communications. Crunkilton et al.'s identified activities and outcomes of capstone courses reinforce Kolb's (1984) belief that learners must be able to utilize self-derived ideas to make decisions and solve problems.

The MIELCC

According to Andreasen (1998), there is an extensive gap in capstone course literature establishing the linkage of experiential learning activities into the curricula. To address this apparent gap, Andreasen developed a model incorporating experiential learning activities into capstone course curricula. The resulting model, the Model for Integration of Experiential Learning into Capstone Courses (MIELCC) (Figure 2.6), provides a conceptual framework for this 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 communications (Andreasen, 1998).The next section of the MIELLCC integrates several major theories of experiential learning, where receiving, relating, reflecting, refining, and reconstructing information (the five R's) act as a funnel to synthesize content (Andreasen, 1998).

The first R, receiving, 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 second R, relating, is concerned with linking learned experiences to previously gained knowledge to better integrate experiential learning into the capstone course philosophy (Andreasen, 1998). The third R, reflecting, is what other experiential learning models refer to as internalized reflection (Piaget, 1971), reflective observation (Kolb, 1984), or sharing and processing (Cooperative State Research, Education, and Extension Service [CSREES], 1992).

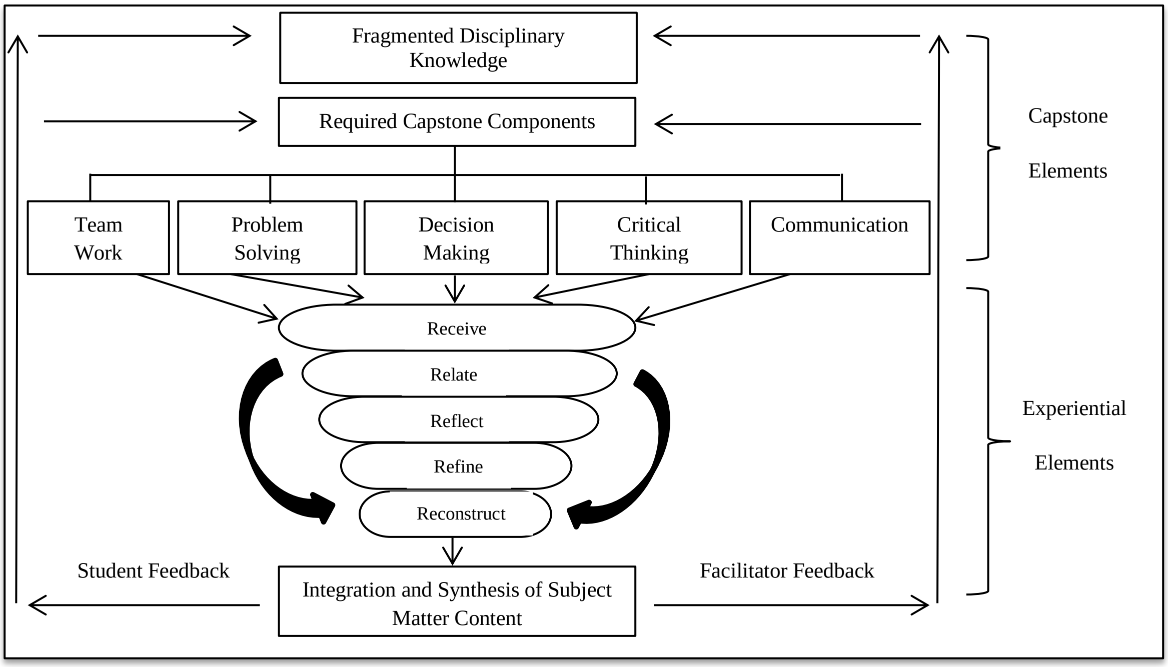

Figure 2.6. The Model for Integration of Experiential Learning into Capstone Courses From Andreasen, 2004, p. 55. Reprinted with permission.

Reflection occurs when students purposefully reflect upon experiences received and begin to relate them to other scenarios. 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). This stage is associated with the abstract conceptualization (Kolb, 1984) and generalizes (CSREES, 1992) stages of other experiential learning models.

The final R, reconstruction, allows for synthesis of content so it can be integrated into useable knowledge and applied to different situations or practices (Andreasen, 1998). The Lewinian (1951) model associates this stage with testing implications of new concepts in new situations. The CSREES (1992) model associates this stage with applying newly attained knowledge to a similar or different situation. Then, the MIELLCC concludes in a cyclical manner, where student and facilitator feedback advert to the original starting point of the model, fragmented disciplinary knowledge. The newly found knowledge resulting from the process is then added with other similar or conflicting knowledge and reprocessed again.

AgEdS 450. The capstone course examined as part of this study is the AgEdS 450 farm management and operations course. The AgEdS 450 course was created in 1943 by Dr. William G. Murray to provide graduating seniors in a production agriculture major the opportunity to gain working knowledge or training in at least four fields: (1) farm practices, (2) scientific principles of crop and animal production, including the use of power and equipment, (3) business principles of farming, and (4) making management decisions (Murray, 1945). A 187-acre farm that included a house, barn, corn crib, and other various buildings was purchased in 1942 for the course. Cropping enterprises on the original farm included corn, soybeans, oats, hay, and pasture, and animal enterprises varied from poultry to cattle to swine (Honeyman, 1983).

Although the initial concept of the course remains intact, the operational enterprises and course structure have changed drastically. The AgEdS 450 farm's cropping enterprise now relies solely on corn and soybeans, and the animal enterprise consists of a custom finishing swine operation. The farm owns approximately 250 acres and custom works an additional 1,400 acres for Iowa State University (ISU) (ISU, n.d.). Custom operations include cultivating, planting, and harvesting. The course is required by all Agricultural Studies majors within the department of Agricultural Education and Studies (AgEdS), but is available to all majors. Day-to-day managerial and operational decisions are made and achieved by the students through structured business meetings comprised of eight representative committees—buildings and grounds, public relations, finance, marketing, crops, custom operations, swine operations, and machinery. Students self-select into committees for the entire semester-long course. The course is further broken into two laboratory sections, each meeting once a week at the farm for four hours and each lab section contains representatives from all eight committees (Paulsen, 2013).

The AgEdS 450 course allows students the opportunity to apply prior technical content knowledge and skills of production and 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) suggestions, current educational outcomes of the AgEdS 450 course include teamwork, problem solving, critical thinking, communications, and decision-making (Paulsen, 2013). Specific course activities include written reports, issues analysis, oral presentations, industry involvement, and tasks associated with the upkeep and maintenance of the farm.

Summary

Critical thinking conceptualization varies from simplistic definitions surrounding the analysis and evaluation of information to complex developmental models addressing the generalization of thoughts across contexts. Critical thinking is situated in foundational experiential learning and practical inquiry theories central to education. Yet, much is to be determined regarding influential factors affecting critical thinking development. This study intends to describe the current critical thinking abilities of undergraduate agriculture education and studies students, and to explore how entry pathway and enrollment in a capstone course affect these abilities.

CHAPTER III. METHODS

The Critical Thinking Assessment Test (CAT) developed by Tennessee Technological University was utilized to assess the current critical thinking abilities of undergraduate students within the Department of Agricultural Education and Studies (AgEdS), as well as to explore potential factors influencing the development of these abilities. Contents of this chapter include an explanation of the CAT instrument, a description of the participants, details of data collection methods, and an explanation of statistical analyses utilized.

Objectives of the Study

The purpose of this study was to describe the current critical thinking abilities of undergraduate agriculture education and studies students, and to explore how entry pathway and enrollment in a capstone course affect these abilities. The following research objectives guided the study:

1. Establish a departmental benchmark for critical thinking abilities of undergraduate agricultural education and studies students.
2. Determine if entry pathway, direct from high school admittance versus transfer from community college admittance, had an effect on the critical thinking abilities of agricultural education and studies students.
3. Explore the impact a semester-long capstone farm management course had on the development of undergraduate agricultural education and studies students' critical thinking abilities.

Instrument

This study utilized the CAT instrument, 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 includes fifteen, short-answer questions, based on real-world situations developed by university faculty across the nation to accurately assess fifteen 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 are utilized to enhance consistency and reliability in evaluations of the completed instruments.

The CAT instrument was designed to evaluate the effects of college education, a program of study, a specific course, and informal learning experiences (CAIL, 2012). Appropriate assessment methods for the CAT include "pre-test/post-test, cross-sectional studies, evaluation of changes in program outcomes over time, and evaluation of changes in programs or courses by comparison to a control group" (CAIL, 2012, p. ii). The CAT evaluates four overarching domains of critical thinking: (1) evaluating information and other points of view, (2) creative thinking, (3) learning and problem solving, and (4) communication. Within these four domains, fifteen individual skill areas were identified. The fifteen specific skill areas assessed by the CAT instrument (Figure 3.1) 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 3.1. Specific skill areas assessed by the CAT (CAIL, 2012).

CAIL (2010) reported inter-rater reliability examinations on the CAT at the level .82. Gall, Gall, and Borg (1996) claimed reliability coefficients .80 or higher were "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 a 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, the CAT instrument has been shown to possess neither floor nor ceiling effects (CAIL, 2010). A reliability check from CAIL revealed scoring was within acceptable error and, therefore, can allow for comparisons to national norm data.

Objectives One and Two

Due to the nature of the study, different data collection and analyses methods were used for different objectives. Objective one sought to establish a departmental benchmark for critical thinking abilities of undergraduate agricultural education and studies students. Objective two sought to determine if entry pathway, direct from high school admittance versus transfer from community college admittance, had an effect on critical thinking ability. Objectives one and two utilized the same participants, data collection methods, and data analysis methods.

Participants

All senior level undergraduates (*N*=181) in the Department of AgEdS at ISU during the spring 2013 semester were identified as the target population for objectives one and two. Consistent with ISU's definition, it was predetermined that students who had earned at least 90 semester credit hours at the time of the ten-day enrollment list qualified as having senior-level status. The ten-day enrollment list was selected as the sampling frame because it met the recommendations of Dillman, Smyth, and Christian (2009) regarding reducing coverage error.

1. The list contained everyone in the survey population.
2. The list did not include names of people who were not in the study population.
3. The list was well maintained and updated.
4. The sample units included were on the list only once.
5. The list contained other information that could be used to improve the study.

The ten-day enrollment list met the outlined recommendations in that: (1) it contained all students within the population; (2) it did not include any students who were not considered a part of the population; (3) it was updated through the Office of the Registrar, so it contained the most up-to-date contact information for the students; (4) it did not duplicate students, resulting in each student having a “known, non-zero chance of being selected into the sample” (Dillman et al., 2009, p. 54); and (5) it provided demographic and academic information used to address other research objectives.

Dillman et al. (2009) claimed the most common way to achieve a simple random sample is through the use of a computerized random number generator that selects participants. Alphabetized lists are preferred as they avoid “periodicity” (p. 61). A computerized random number generator was utilized to compile a simple random sample of the alphabetized names on the ISU ten-day enrollment list to achieve a representative sample size of 124 students. The following formula presented by Dillman et al. (p. 56) was used to determine sample size at a 95% confidence level.

1. $N_S = \dfrac{(\mathrm{Np})(p)(1-p)}{(\mathrm{Np}-1)(B/\mathrm{C})^2 + (p)(1-p)}$

2. $N_S = \dfrac{(181)(0.5)(1-0.5)}{(181-1)(.05/1.96)^2 + (0.5)(1-0.5)}$

3. $N_S =$ 123.25 = 124

The following is an explanation of the variables used above. N_S = the completed sample size needed for the desired level of precision; Np = the size of the population; p = the proportion of the population expected to choose one of the two response categories; B = the margin of error; and C = Z score associated with the confidence level (1.96 corresponds to the 95% level).

Utilizing a sample instead of attempting to access the entire population was completed in accordance with Dillman et al.’s (2009) recommendation for collecting a representative sample because "attempting to collect the entire population is only going to realistically reduce the margin of error by small percentages while increasing resources drastically" (pp. 59-60). Further, Dillman et al. posed it is more appropriate in regards to minimizing non-response error to have a higher response rate of a sample than a lower response rate of a population.

Non-Response Error

Even after following suggested contact protocol, non-response error can still be problematic. Dillman et al. (2009) described non-response error as "occurring when the people selected for the study who do not respond are different from those who do respond in a way that is important to the study" (p. 17). Handling non-response error is 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. Multiple methods were utilized in this study in an attempt to address the non-response error.

As Dillman et al. (2009) suggested, an incentive was used to reduce non-response error. Lunch was provided for participants agreeing to take the CAT assessment. Students' first names were used in contact emails to increase response rate (Dillman et al., 2009). Linder et al. (2001) suggested addressing non-response error by comparing non-respondents to respondents. Recommendations for this method required a minimum of 20 responses from a randomly selected group of non-respondents. This method was not feasible, since collection of the minimum number of responses was not accomplished.

As a result, non-response error was addressed following the suggestions of Miller and Smith (1983) by comparing respondents' and non-respondents personal and demographic data to known population data obtained from the Office of the Registrar's ten-day list. Non-response data were coded and analyzed using PASW Statistics 18. A Pearson's χ^2 analysis yielded no significant difference ($p > .05$) for gender and a two-sample *t*-test yielded no significance differences ($p > .05$) for age, cumulative grade point average, and ACT score between respondents and non-respondents. However, caution should be used when extrapolating results beyond those students within the Department of AgEdS, as respondents in objectives one and two were representative of a homogenous sample in regards to educational degree pursuit.

Data Collection

The researcher received Institutional Review Board (IRB) approval from ISU prior to collecting data (Appendix A). A modified version of Dillman et al.'s (2009) Tailored Design Method was followed when requesting student participation. Five points of contact with participants were made (Appendix B): (1) a brief, pre-notice email; (2) a request for participation with a cover letter via email; (3) a reminder letter via email; (4) a second request for participation via telephone; and (5) a final contact via email. A listing of the points of contact and dates implemented can be found in Table 3.1.

The pre-notice email was sent to each of the randomly selected student's campus email (n =124) as identified on the ten-day enrollment list. Students were not required to respond to this contact. The request for participation, along with a cover letter including details of the proposed research, was emailed the following day. Participants were then asked to indicate their willingness to participate. If they indicated interest in participating, an email including a link to an online scheduling tool was returned to the participant. The scheduling tool offered five days toward the end of the spring 2013 semester from which the participants could choose a day to come to a predetermined location on the ISU campus to complete the CAT assessment. Seven days later, the first reminder was sent to non-respondents. For those students still not responding after five days following the first reminder, a second reminder was made via phone to the number provided on the ten-day enrollment list. A final attempt to solicit participation was made via email three days following the phone calls.

Table 3.1

Participant Contact Schedule for Objectives One and Two

Day of contact	Reason for contact
February 19, 2013	Pre-notice email – announced study, provided limited background.
February 20, 2013	Request for participation email – purpose of the study, consent information, and link to online scheduling tool.
February 27, 2013	Follow-up email to non-respondents – reminder about the purpose, consent information, and link to online scheduling tool.
March 4, 2013	Follow-up phone call to non-respondents – reminder about the email request, purpose of the study, and verbal scheduling.
March 7, 2013	Follow-up email to non-respondents – reminder about the purpose, consent information, and link to online scheduling tool.

Included in the 124 students randomly selected to participate in objectives one and two were 35 respondents who were also needed to complete the pre-/post-test design of objective three. The post-test scores of the overlapping 35 respondents were used to explore objectives one, two, and three, since no test-retest effect exists for the CAT

(CAIL, 2010). The post-test scores of the overlapping 35 respondents were included rather than the pre-test scores because the date the post-tests was administered was within one week of the test administration date of the randomly selected students represented in objectives one and two, and reflected near completion of the capstone course. Of the remaining 89 randomly selected students, who were not a part of the pre-test/post-test study, 40 completed the CAT assessment. These efforts yielded 75 completed tests (Table 3.2), 60.48% of the 124 randomly selected senior-level students.

Table 3.2

CAT Test Completion Date and Number of Tests for Objectives One and Two

Date of completion	Group	Number of Tests
April 22, 2013	Assessment completed during personal time	10
April 23, 2013	Assessment completed during personal time	9
April 24, 2013	Assessment completed during personal time	8
April 26, 2013	Assessment completed during personal time	5
May 1, 2013	Pre-test/post-test design, section one, capstone course	16
May 2, 2013	Pre-test/post-test design, section two, capstone course	19
May 3, 2013	Assessment completed during personal time	8
Total		75

Data Analysis

The first objective of this study was to establish a departmental benchmark for critical thinking abilities of senior-level undergraduate agricultural education and studies students. Measures of central tendency were utilized to describe demographic and academic characteristics. University-specific terminology was used to describe participants' academic characteristics. Semester credit hours included the number of credit hours 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 and the present study was also conducted for objective one (Gall et al., 1996). This objective further 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 gender, age, semester hours completed, semester GPA, cumulative hours, cumulative GPA, total hours, and ACT score. Variables were entered in PASW using stepwise multiple regression to link predictor variables to criterion variables where criterion variables were continuous, and predictor variables were continuous and nominal (Gall et al., 1996). Effect sizes quantifying group differences were interpreted using Cohen's (1992) criteria, where 0.02 is small, 0.15 is medium, and 0.35 is large.

Objective two sought to determine if there was a statistical difference in the critical thinking abilities of students who entered college directly from high school versus those who transferred from a community college. Measures of central tendency were used to describe demographic and academic characteristics. A two-sample *t*-test was utilized to compare the academic characteristics of students according to collegiate entry pathway (Gall et al., 1996). A two-sample *t*-test was utilized to compare the critical thinking assessment scores of students according to entry pathway (Gall et al., 1996). A one-sample *t*-test utilizing CAT national norm data collected from junior and senior-level higher education students across the nation and the present study was also conducted (Gall et al., 1996).

Objective Three

Participants

Objective three sought to explore the impact a semester-long capstone farm management course had on the development of undergraduate agricultural education and studies students' critical thinking abilities. All undergraduate students enrolled (N = 54) in the capstone farm management course during the spring 2013 semester were considered the population for this study. This group was purposively selected in an attempt to examine potential gains in critical thinking and problem solving abilities through enrollment and participation in a culminating capstone course experience. Since the capstone course was divided into two separate laboratory sections, demographic and academic characteristics of all students (N = 54) enrolled in the capstone course were compared according to laboratory section. A Pearson's χ^2 analysis yielded no significant difference ($p > .05$) for gender and a two-sample *t*-test yielded no significant differences ($p > .05$) for age, semester hours, semester grade point average (GPA), cumulative hours, cumulative GPA, total hours, or ACT score. Thus, data analyses and reporting were conducted without differentiation according to laboratory section.

Data Collection

Several studies have utilized pre-test/post-test designs to evaluate the effects an educational experience has on the development of students' critical thinking abilities. Bers, McGowen, and Rubin (1996) examined changes in the critical thinking abilities of community college students over the course of one semester. Friedel et al. (2008) explored the effects of overtly teaching critical thinking in an undergraduate biotechnology course for one semester. Iwaoka, Li, and Rhee (2010) examined how problem-based learning activities influenced the critical thinking abilities of undergraduate food science and human nutrition students over the course of one semester. Further, the CAT is an appropriate instrument for pre-test/post-test designs, since it possesses a test-retest reliability coefficient greater than .80 (CAIL, 2010). The pre-tests and post-tests utilized for this study were administered separately in each of the two laboratory sections of the course during weeks one and 15 of the 16-week, spring 2013 semester.

Of the paired tests administered to the students in the capstone course (N = 54), 45 matched pairs were compiled. Several students were unable to complete both because of absences during either the pre-test or post-test administration dates. The anticipation of limited resources, primarily faculty scorers' time, resulted in the necessity to pare down the quantity of assessments scored. Although CAIL (2013) determined a minimum of ten matched pairs to be sufficient in evaluating changes in critical thinking and problem solving abilities through a pre-test/post-test design, available resources allowed for 25 paired assessments to be randomly selected from the alphabetized list of all 54 students enrolled in the capstone course and scored for this study.

Data Analysis

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). Typical to educational research, statistical significance was set a-priori at $p < .05$ (Gall et al., 1996). Paired sample *t*-tests were utilized to determine if enrollment in a capstone farm management course for a single semester made a statistical difference ($p < .05$) in students' critical thinking abilities. A one-sample *t*-test utilizing CAT national norm data collected from junior and senior-level higher education students across the nation was also conducted. Participants' post-test scores were utilized for this comparison to take into account any effects of enrollment in the capstone course. Effect sizes quantifying group differences were interpreted using Cohen's (1992) criteria, where 0.02 is small, 0.15 is medium, and 0.35 is considered as having a large effect.

Limitations

Data were collected from within the Department of AgEdS and were representative of a homogenous sample in regards to educational department classification. Therefore, care should be used when generalizing beyond those outside the Department of AgEdS. However, the data still offer insight for other institutions regarding factors influencing the critical thinking abilities of undergraduate students as well as the role a capstone farm management course can have on students' critical thinking abilities. The broad concept of critical thinking used in this study was limited to the fifteen specific skill areas measured by the CAT.

Summary

The purpose of this study was to describe current critical thinking abilities of undergraduate agriculture education and studies students, and to explore how entry pathway and enrollment in a capstone course affect these abilities. Objectives one and two utilized a random sample of all senior-level undergraduates in the Department of AgEdS to establish a benchmark for critical thinking ability, as well as to determine the effect entry pathway had on students' critical thinking abilities. Objective three utilized a pre-/post-test design to explore the impact a semester-long capstone farm management course had on the development of students' critical thinking abilities.

This study utilized the CAT instrument to address each objective. The CAT is a National Science Foundation supported tool created to assess and improve critical thinking and real-world problem solving skills. The CAT was designed to evaluate the effects of college education, a program of study, a specific course, and informal learning experiences. Data collection, analysis, and reporting varied according to objective. Data analyses methods included measures of central tendency, *t*-tests, and multiple regressions. Caution should be used when extrapolating results beyond those students within the Department of AgEdS, since respondents were representative of a homogenous sample in regards to educational degree pursuit.

CHAPTER IV. ESTABLISHING A BENCHMARK FOR CRITICAL THINKING WITHIN A DEPARTMENT OF AGRICULTURAL EDUCATION AND STUDIES

A paper prepared for submission to the *Journal of Agricultural Education.*

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Thomas H. Paulsen

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 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.

Introduction

Recent reform in higher education reflects an emphasis on critical thinking, problem solving, and communications (Paul, 1995; Rhodes, Miller, & Edgar, 2012; Willsen, 1995; Wright, 1992). Possessing critical thinking abilities as a college graduate has continually been identified as a desired outcome by universities and employers (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 students' abilities to explain concepts in their own words equate 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 keep in mind critical thinking is not simply a random compilation of components (Willsen, 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 (Willsen, 1995).

Higher education institutions often face the challenge of examining and assessing students' critical thinking abilities. Wagner (2008) identified problem solving, accessing and analyzing 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): (1) evaluate and interpret information, (2) problem solving, (3) effective communication, and (4) 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 (Willsen, 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" (Willsen, 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 the 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, gender, grade point average (GPA), and age (Ricketts & Rudd, 2005). When researching broad teaching and learning components, gender is continually identified as a key factor (Bers, McGowen, & Rubin, 1996). However, little consistency surrounds the role of gender in critical thinking development. Some research suggested the rate of critical thinking development among males is higher than for females (King, Wood, & Mines, 1990), while other research suggested females possess higher critical thinking abilities (Bers et al., 1996; Rudd et al., 2000). Yet, gender 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 ($p < 0.01$) 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 gender as predictor variables in regression analyses (Jacobs, 1995).

Problem Statement

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 agriculture education and studies 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 4.1). 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). For this study, the model provided a platform for making recommendations to instructors regarding specific approaches that can assist in developing students' critical thinking abilities.

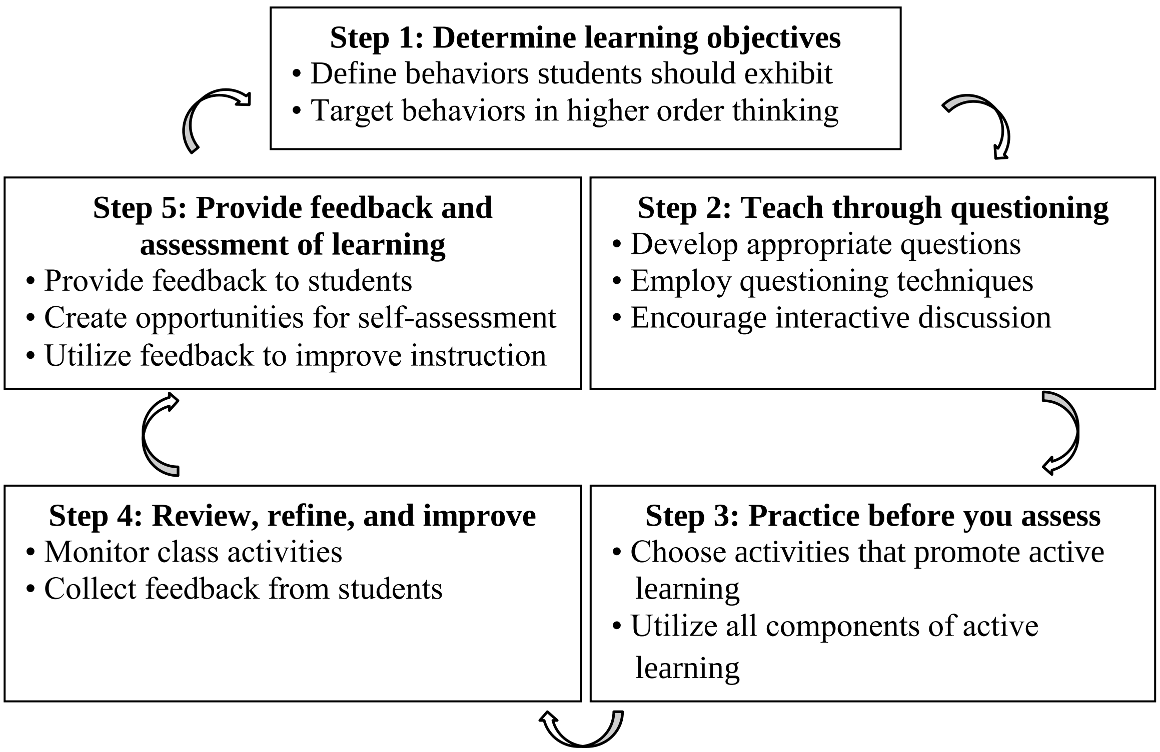

Figure 4.1. 5-Step Model to Move Students Toward Critical Thinking (Duron et al., 2006).

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. Describe selected demographic and academic characteristics of agricultural education and studies students.
2. Report agricultural education and studies students’ critical thinking scores in reference to national user norms.
3. 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) within the Department of Agricultural Education and Studies (AgEdS) 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 population was conducted to enable comparisons among the students randomly sampled. This analysis revealed the typical student in the 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 fifteen short answer questions based on real-world situations developed by university faculty across the nation to accurately assess fifteen 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 fifteen specific skill areas assessed by the CAT instrument (Figure 4.2) were developed and validated by an interdisciplinary team of faculty (CAIL, 2013), thus establishing face validity. The fifteen specific skill areas were further grouped into four overlapping broad categories: (1) creative thinking, (2) problem solving, (3) evaluate and interpret information, and (4) effective communication.

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 4.2. 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. 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 calculated the question a third time. Internal consistency of the instrument 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. A reliability check from CAIL revealed scoring was within an acceptable error and, thus, allowed for comparisons to national norm data.

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 gender 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 in regards to 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 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 reflects 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 gender, 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

The first research objective sought to describe the demographic and academic characteristics of participating agricultural education and studies students. Table 4.1 contains a summary of participants' demographic information. 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 4.1

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

	f	%
Gender		
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 4.2 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 4.2

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

	M	*SD*
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

Objective two sought to report agricultural education and studies students' critical thinking scores in reference to national user norms. Table 4.3 displays *t*-test analyses of participants' scores for each skill area of the CAT as compared to the upper level CAT national norms. Table 4.3 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 fifteen 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 4.3

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 *M*	Institution *SD*	National *M*	National *SD*	Diff.[e]	*t*	*df*	*p*[f]	Effect Size[g]
X				Summarize pattern of results.	0.79	0.41	0.67	0.46	0.12	0.09	72	.02*	0.29
		X	X	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
				Evaluate whether information									

Table 4.3 Continued

X				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/pooled group *SD* (0.1 – 0.3 = small; 0.3 – 0.5 = moderate; > 0.5 = large); * = significant at $p < .05$.

Objective three 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, gender, 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 4.4). At step one of the analysis, the ACT score entered into the regression equation and 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 score. 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 ($t = 0.190$, $p > .05$), gender ($t = -1.289$, $p > .05$), 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 x ACT score + 8.810.

Table 4.4

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, Gender

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. Research objective one was to describe selected demographic and academic characteristics of the agricultural education and studies students. Participants in this study were statistically similar in demographic and academic characteristics of the population.

The second research objective was to report agricultural education and studies students' critical thinking scores in reference to national user norms. It should be mentioned CAT national norms are representative of college students across the nation enrolled in a multitude of academic majors. 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 relationship to national norm data. 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 second research objective led to the conclusion that ISU agricultural education and studies students' possessed adequate problem solving abilities but needed 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 anticipated 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.

The researchers concluded agricultural education and studies students did not possess strong creative thinking abilities. This conclusion mirrors similar undergraduate agriculture student research (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.

The researchers further concluded college entrance exams remain consistent predicators of critical thinking ability. Findings from objective three indicated students' ACT scores as the only significant predictor of overall critical thinking ability. This finding closely mirrored 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 $p < 0.01$ 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 current research, gender cannot be definitely concluded as a predictor of critical thinking ability. Findings of the third research objective indicated that gender was not significantly related to overall critical thinking ability. This finding aligns with the research of Brahmasrene 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 in regards to gender. Research exploring the relationship of gender 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 effectively communicate. Regardless, agricultural education instructors should create activities and utilize pedagogical approaches that focus on developing their students' critical thinking abilities founded in creative thinking and effective communication.

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. Duron et al.'s model would first suggest determining learning objectives that facilitate creative thinking and effective communication. Their model recommends 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 courses or activities more successful at developing critical thinking? 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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CHAPTER V. COMPARING DIFFERENCES IN CRITICAL THINKING ABILITY ACCORDING TO COLLEGIATE ENTRY PATHWAY

A paper prepared for submission to the *Journal of Agricultural Education.*

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Abstract

Developing competencies, such as critical thinking, that enable individuals to participate fully as citizens remains the unifying purpose of public education (Kuhn, 1999). Critical thinking is developed as a result of disposition and a set of facilitating factors, which include training and experience (Ricketts & Rudd, 2005). The purpose of this study was to determine if entry pathway, direct from high school admittance versus transfer from community college admittance, has an effect on the critical thinking abilities of agricultural education and studies students. Seventy-five senior-level agriculture undergraduate students completed a critical thinking assessment test during the spring 2013 semester. Results indicated, although students entering the four-year university directly from high school possessed statistically significant higher ACT scores and semester GPA's, known predictors of critical thinking ability, no statistical differences were found when comparing the critical thinking abilities of the two groups. Results also indicated that both groups demonstrated lower abilities in the creative thinking domain of the critical thinking assessment.

Introduction

Although developing competencies, such as critical thinking, enable individuals to participate fully as citizens remains the unifying purpose of public education (Kuhn, 1999), a universally-accepted idea of what constitutes critical thinking does not exist (Tsui, 1998). Defining critical thinking involves both simplistic explanations focused primarily on analyzing and evaluating information (Duron, Limbach, & Waugh, 2006), and complex explanations where critical thinking is seen 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 is believed present when students perform in the higher-ordered thinking levels of Bloom’s (1956) taxonomy, such as in the *Analysis, Synthesis*, and *Evaluation* levels (Bers, 2005; Duron et al., 2006). A critical thinking focus is evident in the *Analysis* level when the functionality of parts is explored, in the *Synthesis* level when the parts are placed together to form an original whole, and in the *Evaluation* level when the whole is valued and judged (Duron et al., 2006).

Comparative to the individual components of various critical thinking definitions, Wagner (2008) identified problem solving, accessing and analyzing information, effective oral and written communications, and curiosity and imagination among a set of skills students need to be successful in higher education. These four skill areas align with broad domains of numerous critical thinking assessments as well as with the specific domains of the instrument utilized in this study, the Critical Thinking Assessment Test (CAT). The CAT is an open ended, 15-question instrument that assesses critical thinking and real-world problem solving skills by exploring individuals' abilities to evaluate and interpret information, solve problems, communicate effectively, and think creatively.

According to Jacobs (1995) and Fawkes (2001), a few examples of other widely known critical thinking assessments include the Watson-Glaser Critical Thinking Appraisal (WGCTA) (Watson & Glaser, 1980), the Cornell Critical Thinking Test (CCTT) (Ennis, Millman, & Tomko, 1985), and the California Critical Thinking Skills Test (CCTST) (Facione, 1992). The WGCTA is a multiple choice formatted test designed to measure various interdependent aspects of critical thinking through different constructs identified as inferences, recognition of assumptions, deduction, interpretation, and evaluation of arguments (Hassan & Madhum, 2007). The CCTT is also a multiple choice question test that provides a single score based on measurable items in induction, deduction, evaluation, observation, credibility of statements, identification of assumptions, and the ability to discern meaning (Jacobs, 1995). The CCTST is yet another multiple choice question assessment meant to yield sub-scores representing analytic, evaluation, and inferential abilities.

Irrespective of critical thinking definition or assessment instrument preference, critical thinking is developed as a result of critical thinking disposition and a set of facilitating factors, which include age, gender, grade point average (GPA), training, and experience (Ricketts & Rudd, 2005). Critical thinking disposition is an individual's motivation to use critical thinking skills (Pascarella & Terenzini, 2005). In a study exploring the relationship between critical thinking dispositions and problem solving abilities of undergraduate agriculture students, Friedel, Irani, Rhoades, Fuhrman, and Gallo (2008) concluded "students with a preference to solve problems by generating many solutions and employing a strategy of thoroughness and attention to detail" (p. 34) possess higher critical thinking dispositions. While Brisdorf-Rhoades, Ricketts, Irani, Lundy, and Telg (2005) found greatly varying critical thinking dispositions among undergraduate agriculture communication students, Rudd et al. (2000) found students enrolled in one college of agriculture did not possess strong dispositions to think critically.

The link between critical thinking disposition and two of the facilitating factors of overall critical thinking ability, age and gender, is not clear. Bers et al. (1996) and Rudd et al. (2000) found females possessed greater critical thinking dispositions than males. However, Brisdorf-Rhoades et al. (2005) and Burbach, Matkin, Quinn, and Searle (2012) were unable to find significant gender relationships. Similar discrepancies are evident between critical thinking disposition and age. Bers et al. (1996) and Jacobs (1995) found a significant positive relationship between disposition and age, but Burbach et al. (2012) found no significant linkage. Research exploring the relationship of gender to overall critical thinking ability provides slightly more consistency than that of a disposition. Gender has been shown to possess limited to no significant influence on critical thinking ability (Brahmasrene & Whitten, 2011; Friedel, Irani, Rudd et al., 2008).

Another facilitating factor of critical thinking is GPA. Most students with high critical thinking skills are likely to perform well in college courses (Williams & Stockdale, 2003). Collegiate GPA was found one of the most consistent predictors of critical thinking disposition among undergraduate agriculture students (Burbach et al., 2012; Friedel, Irani, Rhoades et al., 2008). Brahmasrene and Whitten (2011) were able to link incoming undergraduate business students' high school GPA's to overall critical thinking ability. Similarly, Ricketts and Rudd (2005) found a positive correlation between GPA and overall critical thinking ability of National FFA delegates when leadership and innovativeness constructs were held constant.

The remaining two facilitating factors of critical thinking, experience and training, were the focal point of this study. While some studies (e.g., Bers et al., 1996, Burbach et al., 2012) found significant positive relationships between level of education (freshman, sophomore, junior, or senior classification) and critical thinking disposition, contradicting evidence has also been presented (Brisdorf-Rhoades et al., 2005). Recognizing that some gains could be attributed to natural development that would have occurred in the absence of college, Saavedra and Saavedra (2011) found students in their final year of college possessed statistically significant higher critical thinking abilities than first year students. Although these studies found increases in student critical thinking disposition and ability over the span of a four-year degree, definitively attributing casual relationships to these increases is more difficult.

Gellin (2003) provided a possible explanation for these increases in the discovery that students continually involved in co-curricular activities achieved higher gains in critical thinking compared to those who were not involved. Delving deeper into the effects experience and training have on critical thinking development, Jacobs (1995) compared the critical thinking dispositions of traditionally-aged community college students to those of entering freshmen at a private university (Facione, Sanchez, Facione, & Gainen, 1994). Findings indicated the community college group possessed weaker dispositions to think critically than the incoming freshmen of the private university.

Problem Statement

Although critical thinking disposition is related to critical thinking ability (Ricketts & Rudd, 2005; Friedel, Irani, Rudd, et al., 2008), an individual's disposition to think critically is a factor that should be examined with caution, since it leaves a lot of unaccounted variance (Kuhn, 1999). Disposition is often interpreted in the sense of habit, but individuals do not employ critical thinking from habit, but rather they employ critical thinking because they see the value in doing so (Kuhn, 1999). Therefore, studies exploring critical thinking ability should be conducted. Specifically, a need exists to explore critical thinking ability in regards to the facilitating factors of experience and training. Research has shown weaker critical thinking dispositions among community college students as compared to entering freshmen at a private university (Jacobs, 1995). However, limited research exists exploring the critical thinking abilities of similar group comparisons. Do critical thinking abilities of students who enter a four-year university directly from high school vary from those of students who transfer from a community college?

Purpose and Objectives

As part of a larger investigation, the purpose of this study was to determine if entry pathway, direct from high school admittance versus transfer from community college admittance, had an effect on the critical thinking abilities of agricultural education and studies students. The following research objectives guided this study:

1. Compare selected demographic and academic characteristics of agricultural education and studies students as categorized by entry pathway.

2. Compare the critical thinking abilities of students who entered the four-year university directly from high school to the critical thinking abilities of students who entered via transfer from a community college.
3. Compare the critical thinking abilities of students who entered the four-year university directly from high school to national critical thinking norms.
4. Compare the critical thinking abilities of students who entered the four-year university via transfer from a community college to national critical thinking norms.

Methods and Procedures

Population and Sample

The target population of this study was identified as all senior-level undergraduates (90+ semester credit hours; N = 181) within the Department of Agricultural Education and Studies (AgEdS) at Iowa State University (ISU) during the spring 2013 semester. Entry pathway was determined according to the ISU Registrar's official classification. As recommended by Dillman, Smyth, and Christian (2009), the ISU ten-day enrollment list was utilized to achieve a random representative sample size of 124 students at a 95% confidence level. An analysis of the population's demographic and academic information was conducted to enable comparisons among the sample. In comparing sample demographic and academic information to population data, a Pearson's χ^2 analysis yielded no significant difference ($p > .05$) for gender and multiple two-sample *t*-tests yielded no significance differences ($p > .05$) for age, semester credit hours, semester GPA, cumulative credit hours, cumulative GPA, transfer credit hours, transfer GPA, total GPA, and ACT score.

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 fifteen short answer questions based on real-world situations developed by university faculty across the nation to accurately assess 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.

Among other uses, the CAT instrument is designed to evaluate the effects of a collegiate program of study (CAIL, 2012). The fifteen specific skill areas assessed by the CAT instrument (Figure 5.1) were developed and validated by an interdisciplinary team of faculty representing various institutions (CAIL, 2013), thus establishing face validity. The fifteen specific skill areas are further grouped into four overlapping broad categories according to question topic: (1) creative thinking, (2) problem solving, (3) evaluate and interpret information, and (4) effective communication.

Inter-rater reliability examinations on the CAT indicated consistency at the level of .82 (CAIL, 2010). 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 calculated 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.

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 5.1. Specific Skill Areas Assessed by the Critical Thinking Assessment Test (CAIL, 2012).

Procedure

A modified version of the Dillman et al. (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 is recommended of 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 gender 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, since respondents were representative of a homogenous sample in regards to educational degree pursuit.

Measures of central tendency were used to describe demographic and academic characteristics in objective one. A two-sample *t*-test was utilized to compare academic characteristics according to entry pathway in objective one (Gall et al., 1996). 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 include the number of credit hours taken at the current university and cumulative GPA reflects 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 two-sample *t*-test was utilized for objective two to compare the critical thinking assessment scores of participants who entered the four-year university directly from high school to those who transferred from a community college (Gall et al., 1996). A one-sample *t*-test utilizing CAT national norm data collected from junior and senior-level higher education students across the nation and the present study was conducted to address objectives three and four (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

The first research objective sought to compare the demographic characteristics of participating agricultural education and studies students according to entry pathway. Table 5.1 contains a summary of students' demographic information.

Table 5.1

Demographic Information of Direct from High School and Transfer Students (n = 75)

	Direct from HS (*n* = 41)		Transfer (*n* = 34)	
	f	%	*f*	%
Gender				
Male	27	65.9	23	67.6
Female	14	34.1	11	32.4
Age				
Under 20 years of age	2	4.9	0	0.0
21-25 years of age	38	92.7	33	97.1
Over 26 years of age	1	2.4	1	2.9
Race				
White	41	100.0	34	100.0

The students who entered the four-year university directly from high school were primarily males (65.9%) between the ages of 21 and 25 (92.7%). Students who entered the four-year university through transfer from a community college were also primarily males (67.6%) between the ages of 21 and 25 (97.1%). The entire sample (100.0%) self-identified as white. A Pearson's χ^2 analysis yielded no significant difference ($p > .05$) for gender and a two-sample *t*-test yielded no significant difference ($p > .05$) for mean age between the two groups according to entry pathway.

Research objective one also sought to compare the academic characteristics of participating agricultural education and studies students according to entry pathway. Results of this comparison are ranked by difference in mean and displayed in Table 5.2.

The typical student who entered the four-year university directly from high school was enrolled in an average of 14.34 (*SD* = 2.60) semester credit hours and had an average semester GPA of 3.07 (*SD* = 0.72) on a 4.00 scale. The average number of transfer semester credit hours was 17.30 (*SD* = 16.50) with a transfer GPA of 2.74 (*SD* = 1.37). The transfer semester credit hours and GPA of this group was calculated from dual-credit courses transferred to the university from the students' high schools. Total credit hours completed were 114.70 (*SD* = 17.31) with a cumulative GPA of 2.90 (*SD* = 0.54).

The typical student who entered the four-year university through transfer from a community college was enrolled in an average of 14.51 (*SD* = 2.15) semester credit hours and had a semester GPA of 2.72 (*SD* = 0.63). The average number of transfer semester credit hours was 63.72 (*SD* = 14.33) with a transfer GPA of 2.87 (*SD* = 0.61). Total credit hours completed were 113.32 (*SD* = 9.71) with a cumulative GPA of 2.66 (*SD* = 0.56).

A series of two-sample *t*-tests were also conducted for objective one to explore potential differences among semester credit hours, semester GPA, cumulative credit hours, cumulative GPA, transfer credit hours, transfer GPA, total GPA, and ACT score (Table 5.2). Resulting in a large effect size, students entering the four-year university directly from high school possessed statistically significant higher ($p < .05$; $d = 0.76$) ACT scores than those students transferring from a community college. Also resulting in a large effect size, students entering directly from high school possessed a statistically significant higher ($p < .05$; $d = 0.51$) semester GPA than those transferring from a community college.

Table 5.2

Comparison of Academic Information of Direct from High School vs. Transfer Students (n = 75)

	Direct HS (*n* = 41)		Transfer (*n* = *34*)						Effect Size[c]
	M	*SD*	*M*	*SD*	Diff.[a]	*t*	*Df*	*p*[b]	
Cm. H.	94.99	17.98	49.25	16.98	45.74	11.24	73	<.01*	2.62
ACT	22.41	3.08	19.96	3.40	2.45	3.02	64	<.01*	0.76
Tr. H.	114.70	17.31	113.32	9.71	0.85	0.25	73	.80	0.06
Sm. GPA	3.07	0.72	2.72	0.63	0.35	2.19	73	.03*	0.51
Cm. GPA	2.90	0.54	2.66	0.56	0.24	1.91	73	.06	0.44
Tr. GPA	2.74	1.37	2.87	0.61	-0.13	0.52	73	.60	0.13
Sm. H.	14.34	2.60	14.51	2.15	-0.17	0.31	73	.76	0.07
Tr. H.	17.30	16.50	63.72	14.33	-46.42	12.86	73	<.01*	3.01

Note. Cm. = cumulative; Sm. = semester; Tr. = transfer; H = hours.; [a]direct from HS minus transfer; [b]probability of difference; [c]mean difference divided by pooled group *SD* (0.1 – 0.3 = small; 0.3 – 0.5 = moderate; > 0.5 = large). * = significant at $p < .05$

Objective two sought to compare the critical thinking abilities of students who entered the four-year university directly from high school to the critical thinking abilities of students who entered via transfer from a community college. Results from this comparison are ranked by difference in mean and displayed in Table 5.3. Table 5.3 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 fifteen questions of the CAT instrument. Evaluate and interpret information included eight questions, problem solving had eight questions, creative thinking included six questions, and effective communication had nine questions.

No statistically significant differences at the specified level ($p < .05$) were determined between students who entered directly from high school versus students who transferred from a community college. Although not a statistically significant difference, students who entered directly from high school scored higher on seven of the fifteen skill areas, the two groups had identical mean scores on two of the skill areas assessed, and students who entered via transfer from community college scored higher on six of the skill areas assessed.

Objective three sought to compare the critical thinking abilities of students who entered the four-year university directly from high school with national critical thinking norms (Table 5.4). Both resulting in moderate effect sizes, direct from high school students scored statistically lower ($p < .05$) than CAT national norm data in the skill areas of explaining how changes in a problem situation might affect the solution ($d = 0.39$) and identifying additional information needed to evaluate a hypothesis ($d = 0.39$). Resulting in large effect sizes, direct from high school students scored statistically lower (*p* < .05) than national norm data in the skill areas of providing relative alternative interpretations for a specific set of results (*d* = 0.68) and identifying additional information needed (*d* =0.87). Further, direct from high school students recorded statistically lower (*p* < .05, *d* = 0.47) overall critical thinking scores than the national norm data.

Table 5.4 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. Direct from high school students' scores were not statistically different (*p* > .05) than national norms on any of the eight skill areas within the evaluate and interpret information domain. However, direct from high school students 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 effective communication domain.

Table 5.3

T-Test Comparisons of Direct from High School vs. Transfer Students for each Skill Area of the CAT (n = 75)

E/I[a]	PS[b]	CT[c]	EC[d]	Skill Area Assessed	Direct *M*	Direct *SD*	Transfer *M*	Transfer *SD*	Diff.[e]	*t*	*df*	*p*[f]	Effect Size[g]
	X	X	X	Identify additional information.	0.98	1.00	1.25	1.05	0.27	1.12	69	.27	0.30
	X	X	X	Explain how changes might affect a solution.	0.76	0.97	1.02	1.11	0.26	1.09	66	.28	0.28
		X	X	Provide alternatives for results.	1.24	0.94	1.38	0.74	0.14	0.71	73	.48	0.14
X	X			Separate relevant from irrelevant information.	3.03	1.12	3.12	0.91	0.09	0.39	72	.70	0.12
X				Evaluate whether information supports a hypothesis.	0.60	0.50	0.68	0.47	0.08	0.68	71	.50	0.14
	X			Use basic mathematical skills to solve a problem.	0.76	0.43	0.79	0.41	0.04	0.39	72	.70	0.07
				Determine whether an inference									

Table 5.3 Continued

X				is supported by information.	0.56	0.50	0.56	0.50	0.00	0.02	70	.99	0.03
X				Summarize pattern of results.	0.79	0.41	0.79	0.41	0.00	0.01	70	.99	0.02
	X	X	X	Identify additional information.	0.32	0.47	0.29	0.46	-0.02	0.21	71	.83	0.03
		X	X	Give alternative interpretations.	0.46	0.64	0.35	0.49	-0.11	0.85	73	.40	0.18
X			X	Evaluate strength of correlational-type data.	1.23	1.19	1.03	1.06	-0.20	0.75	72	.46	0.17
X	X			Evaluate strength of correlational-type data.	1.15	0.86	0.97	0.83	-0.18	0.92	70	.36	0.21
X	X		X	Identify the best solution.	2.09	1.88	1.84	1.71	-0.25	0.60	70	.55	0.18
X	X		X	Use/apply relevant information.	1.12	0.75	0.82	0.76	-0.30	1.71	70	.09	0.40
		X	X	Provide alternatives for spurious associations.	1.73	0.63	1.41	0.82	-0.32	1.86	61	.07	0.46
				CAT total score	16.55	4.60	16.26	3.59	-0.30	0.32	73	.75	0.07

Note. [a] = evaluate and interpret information; [b] = problem solving; [c] = creative thinking; [d] = effective communication; [e]= transfer minus direct; [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 $p < .05$.

Table 5.4

Results of Direct from High School Students' t-Tests for each Skill Area of the CAT as Compared to National Means (n=41)

E/I[a]	PS[b]	CT[c]	EC[d]	Skill Area Assessed	Direct *M*	Direct *SD*	National *M*	National *SD*	Diff.[e]	*t*	*df*	*p*[f]	Effect Size[g]
		X	X	Provide alternatives for spurious associations.	1.73	0.63	1.56	0.86	0.17	1.73	40	.09	0.23
X				Summarize pattern of results.	0.79	0.41	0.67	0.46	0.12	1.90	38	.06	0.29
X			X	Evaluate strength of correlational-type data.	1.23	1.19	1.21	1.13	0.02	0.08	39	.94	0.01
X	X		X	Use/apply relevant information.	1.12	0.75	1.11	0.64	0.01	0.10	40	.92	0.02
X	X			Identify solutions for a problem.	1.15	0.86	1.18	1.03	-0.03	0.22	39	.83	0.03
	X			Use basic mathematical skills to solve a problem.	0.76	0.43	0.82	0.41	-0.06	0.94	40	.35	0.15
		X	X	Provide alternatives for results.	1.24	0.94	1.35	1.04	-0.11	0.72	40	.48	0.11
				Separate relevant from irrelevant									

Table 5.4 Continued

X	X			information.	3.03	1.12	3.14	0.92	-0.11	0.65	39	.52	0.11
X				Determine whether an inference is supported by information.	0.56	0.50	0.68	0.41	-0.12	1.52	40	.14	0.26
X				Evaluate whether information supports a hypothesis.	0.60	0.50	0.73	0.44	-0.13	1.66	39	.11	0.28
X	X		X	Identify the best solution.	2.09	1.88	2.29	1.81	-0.2	0.67	39	.51	0.11
	X	X	X	Explain how changes might affect a solution.	0.76	0.97	1.15	1.06	-0.39	2.60	40	.01*	0.39
	X	X	X	Identify additional information.	0.98	1.00	1.41	1.25	-0.43	2.74	39	.01*	0.39
		X	X	Provide relevant alternative interpretations.	0.46	0.64	0.93	0.74	-0.47	4.70	40	<.01*	0.68
	X	X	X	Identify additional information.	0.32	0.47	0.82	0.68	-0.5	6.84	40	<.01*	0.87
				CAT total score	16.55	4.60	19.04	6.04	-2.49	3.46	40	<.01*	0.47

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

Objective four was to compare the critical thinking abilities of students who entered the four-year university via transfer from a community college with national norms (Table 5.5). Although not statistically significant at the specified level ($p > .05$), transfer students scored higher than CAT national norm data on two of the fifteen skill areas assessed, which included summarizing a pattern of results in a graph and providing alternative explanations for a pattern of results. Transfer students performed statistically lower ($p < .05$) than national norm data in the skill areas of identifying additional information needed ($d = 0.92$) and providing relevant interpretations for a specific set of results. Transfer students also scored statistically lower ($p < .05$, $d = 0.41$) than national norm data in the skill area of using and applying relevant information. Further, transfer students recorded statistically lower ($p < .05$, $d = 0.58$) overall critical thinking scores than the national norm data.

Table 5.5 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 fifteen 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. Transfer student scores were not statistically different ($p > .05$) than national norms on seven of the eight skill areas within the evaluate and interpret information domain. However, transfer students scored statistically lower ($p < .05$) on two of the eight skill areas within the problem solving domain, on two of the six skill areas within the creative thinking domain, and on three of the nine skill areas within the effective communication domain.

Table 5.5

Results of Transfer Students' t-Tests for each Skill Area of the CAT as Compared to National Means (n=34)

E/I[a]	PS[b]	CT[c]	EC[d]	Skill Area Assessed	Transfer *M*	Transfer *SD*	National *M*	National *SD*	Diff.[e]	*t*	*df*	*p*[f]	Effect Size[g]
X				Summarize pattern of results.	0.79	0.41	0.67	0.46	0.12	1.76	33	.09	0.29
		X	X	Provide alternatives for results.	1.38	0.74	1.35	1.04	0.03	0.26	33	.80	0.04
X	X			Separate relevant from irrelevant information.	3.12	0.91	3.14	0.92	-0.02	0.14	33	.89	0.02
	X			Use basic mathematical skills to solve a problem.	0.79	0.41	0.82	0.41	-0.03	0.37	33	.72	0.06
X				Evaluate whether information supports a hypothesis.	0.68	0.47	0.73	0.44	-0.05	0.66	33	.52	0.12
X				Determine whether an inference is supported by information.	0.56	0.50	0.68	0.41	-0.12	1.40	33	.17	0.27
				Explain how changes might									

Table 5.5 Continued

	X	X	X	affect a solution.	1.02	1.11	1.15	1.06	-0.13	0.69	33	.50	0.12
		X	X	Provide alternatives for spurious associations.	1.41	0.82	1.56	0.86	-0.15	1.05	33	.30	0.18
	X	X	X	Identify additional information.	1.25	1.05	1.41	1.25	-0.16	0.91	33	.37	0.14
X			X	Evaluate strength of correlational-type data.	1.03	1.06	1.21	1.13	-0.18	0.99	33	.33	0.17
X	X			Identify solutions for a problem.	0.97	0.83	1.18	1.03	-0.21	1.46	33	.15	0.22
X	X		X	Use/apply relevant information.	0.82	0.76	1.11	0.64	-0.29	2.20	33	.03*	0.41
X	X		X	Identify the best solution.	1.84	1.71	2.29	1.81	-0.45	1.52	32	.14	0.26
	X	X	X	Identify additional information.	0.29	0.46	0.82	0.68	-0.53	6.63	33	<.01*	0.92
		X	X	Provide relevant alternative interpretations.	0.35	0.49	0.93	0.74	-0.58	6.94	33	<.01*	0.94
				CAT total score	16.26	3.59	19.04	6.04	-2.78	4.53	33	<.01*	0.58

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

Conclusions and Discussion

The purpose of this study was to explore differences between critical thinking abilities of senior-level agricultural education and studies students who entered a four-year university directly from high school and those who entered via transfer from a community college. The findings from this study led to three primary conclusions.

The researchers conclude critical thinking ability is not influenced by collegiate entry pathway. Although students who entered the four-year university directly from high school possessed higher ACT and semester GPA's, known predictors of critical thinking, their critical thinking abilities were not statistically different than those for students who transferred from a community college. Findings indicated students entering the four-year university directly from high school possessed statistically significant higher ACT scores ($p < .05$; $d = 0.76$) and semester GPA's ($p < .05$; $d = 0.51$). Since research claims GPA (Burbach et al., 2012; Friedel, Irani, Rhoades et al., 2008; Ricketts & Rudd, 2005) and standardized collegiate entrance exams (Brahmasrene & Whitten, 2011; Jacobs, 1995) are accurate predictors of critical thinking, direct from high school students' critical thinking abilities were anticipated higher than those for students who transferred from a community college.

However, results indicated no statistically significant differences between the two senior-level groups among any of the fifteen specific skill areas assessed by the CAT instrument. What could have accounted for the leveling of the two groups? Did community college transfer students make exceptional gains in their critical thinking abilities once arrived at the four-year university or did the direct from high school students fail to build upon their presumably elevated critical thinking abilities? What influences, if any, did course selection of both groups possess? Further research is need to not only answer these questions, but to determine if these are even plausible explanations.

The researchers further conclude agricultural education and studies students' abilities to identify relevant information and offer alternative interpretations are below expectations. Regardless of entry pathway, both groups scored statistically lower ($p < .05$) than CAT national norm data in the same skill areas of identifying additional information needed to evaluate a hypothesis and providing relevant interpretations for a specific set of results. This conclusion is of particular importance because an integral aspect of critical thinking is "addressing questions with incomplete evidence and information for which an incontrovertible solution is unlikely" (Rudd et al., 2000, p. 5). Numerous definitions of critical thinking recognize the importance of identifying relevant information and providing alternative interpretations (Duron et al., 2006; Hassan & Madhum, 2007; Jacobs, 1995). Discussions provide ample opportunity for students to identify relevant information and provide alternative interpretations, thus enhancing critical thinking that stems from the introduction of diverse viewpoints (Tsai, 2001).

It can be further concluded agricultural education and studies transfer students possess a greater ability to think creatively than those who entered the four-year university directly from high school. Findings indicated direct from high school students scored statistically lower than national norms on four of the six skill areas within the creative thinking domain, while transfer students only scored statistically lower on two of the six skill areas within the creative thinking domain. The creative thinking abilities of students are important because curiosity and imagination are needed to be successful in higher education (Wagner, 2008) and "students with a preference to solve problems by generating many solutions" (Friedel, Irani, Rhoades et al., 2008, p. 34) possess higher critical thinking dispositions.

It should be remembered the CAT instrument assesses students' evaluative and interpretive, problem solving, creative thinking, and effective communication skills utilizing open-ended responses; meaning effective communication is imperative, due to the high dependence on accurately assessing the open ended responses. Performance on the first three domains relies on participants' abilities to effectively communicate their thought progressions in a manner interpretable by an outside evaluator. Are students' creative thinking abilities actually below expectations or is their performance in this domain more of a reflection of underdeveloped communication skills?

Implications and Recommendations

Conclusions drawn from this study possess implications for curriculum development, learning assessment, and future research. Although not generalizable beyond those students enrolled within the academic department examined, the implication for curriculum development is worthy of review. Since critical thinking ability did not differ according to entry pathway, curricular and instructional approaches for senior-level agriculture education and studies students do not need to differ according to entry pathway. Instead, a directed focus on developing all agriculture education and studies students' abilities to gather additional information required to support a claim and to offer alternative interpretations for results should be integrated into the curriculum. Further, recognizing the importance of creative thinking to student success (Wagner, 2008) and overall critical thinking skill (CAIL, 2012), curriculum and instructional development within agricultural education should focus on intentionally integrating creative and critical thinking. By allowing students to develop unique ideas founded in well-reasoned, logical claims, integration of these two thinking techniques can be accomplished (Bonk & Smith, 1998).

The implication for learning assessment stems from varying assessment instruments available in higher education. This study utilized an assessment instrument that focuses on evaluating and interpreting information, problem solving, creative thinking, and effective communication. Since critical thinking is a dynamic construct, future assessments should utilize instruments that explore other components of critical thinking to compare students according to entry pathway. 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. It is also recommended future critical thinking assessment measures continue to utilize open-ended responses as multiple choice exams may not accurately assess critical thinking ability (Bers, 2005; Fawkes, O'Meara, Weber, & Flage, 2005). However, careful consideration should be taken in the selection of open-ended critical thinking assessments, since a student’s ability to communicate effectively could influence overall reported critical thinking skills.

Implications for continued research emerge from the conclusion identifying differences in creative thinking ability according to entry pathway. Future research should be directed toward thoroughly exploring differences in agricultural education students’ critical thinking abilities according to the specific constructs of critical thinking identified by the CAT. Why were the creative thinking abilities of students who entered the four-year university directly from high school lower than students who transferred from a community college? Is this the result of an emphasis on creative thinking at the community college level or a lack of focus at the four-year university level? The difference could also be attributed to individual variations in student experience/training and timing of the assessment. This study measured critical thinking at the end of students' educational careers. Would results differ if this assessment had been administered at the time of transfer?

Future research conducted at the collegiate level should examine agricultural education curricular differences between the first two years of community college and the first two years at a four-year university. Longitudinal studies conducted at the departmental and/or collegiate level should track agricultural education students' critical thinking development over the span of a four-year degree. Faculty should consider these recommendations for curriculum development, learning assessment, and research to advance the critical thinking area of study.

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CHAPTER VI. THE IMPACT OF A CAPSTONE FARM MANAGEMENT COURSE ON IMPROVING CRITICAL THINKING ABILITIES

A paper prepared for submission to the *Journal of Agricultural Education.*

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Abstract

Current research demonstrates a need for investigation to explore the effects specific course designs or directed activities can have on the critical thinking abilities of higher education students. Specifically, limited research exists on the effect an experiential learning-based capstone course has on the development of critical thinking abilities. All students (N = 54) enrolled in a capstone farm management course completed a critical thinking assessment test through a pre-/post-test design and 25 of the paired tests were analyzed using t-tests. Although no statistically significant increases for overall critical thinking scores were found, there was a significant increase in one sub-skill — summarize a pattern of results in a graph. Findings led to the conclusion the capstone course in this study may place emphases on certain sub-skills of critical thinking development while negating to address others. The key implication for instructors working to increase critical thinking abilities of students in capstone courses is intentional in targeting the development of the wide array of specific skills shown to affect overall critical thinking abilities.

Introduction

Critical thinking is a fundamental, overarching outcome of higher education meant to teach students how to improve their thinking skills (Willsen, 1995). Faculty members perceive the responsibility of helping students develop higher-order thinking skills 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 should acquire and maintain a comprehensive understanding of critical thinking. Yet, there is an apparent general lack of critical thinking knowledge among teaching appointment faculty (Stedman & Adams, 2012), as well as little evidence demonstrating critical thinking development occurs in collegiate classrooms (Tsui, 2001).

Perhaps this general lack of critical thinking knowledge among teaching appointment 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 very basic 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). Within the context of agricultural 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 is defined in numerous ways, but 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 requiring higher-ordered thinking (Facione, 1990). These affective dispositions include inquisitiveness, concern, alertness, trust, self-confidence, open-mindedness, flexibility, understanding, fair-mindedness, honesty, prudence, and willingness to reconsider and revise views, where reflection suggests change is warranted (Facione, 1990). Individuals are more effective thinkers if they exhibit these affective dispositions (Rudd, 2007).

Perhaps one of the most common instructional techniques demonstrated to positively affect 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 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 one-minute paper where students state the main, most clear, or muddiest point in the lecture (Adrian, 2010). Also categorized as active learning, experiential 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)—an in-depth study grounded in a particular discipline that goes beyond the limitations of the current curriculum (Wagenaar, 1993). More specifically, a capstone learning experience is one that cultivates critical thinking, problem-solving, decision-making, teamwork, and communication through the use of multi-disciplinary approaches (Crunkilton, Cepica, & Fluker, 1997; Kranz, 1991). If higher education faculty possesses the ability to improve students’ critical thinking abilities (Burbach et al., 2012; Felder & Brent, 2010) and 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 establishing the linkage of experiential learning activities to the curricula. To address this apparent gap, Andreasen (1998) developed a model incorporating experiential learning activities into capstone course curricula. The resulting model, the Model for Integration of Experiential Learning into Capstone Courses (MIELCC) (Figure 6.1), provided a conceptual framework for this 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).

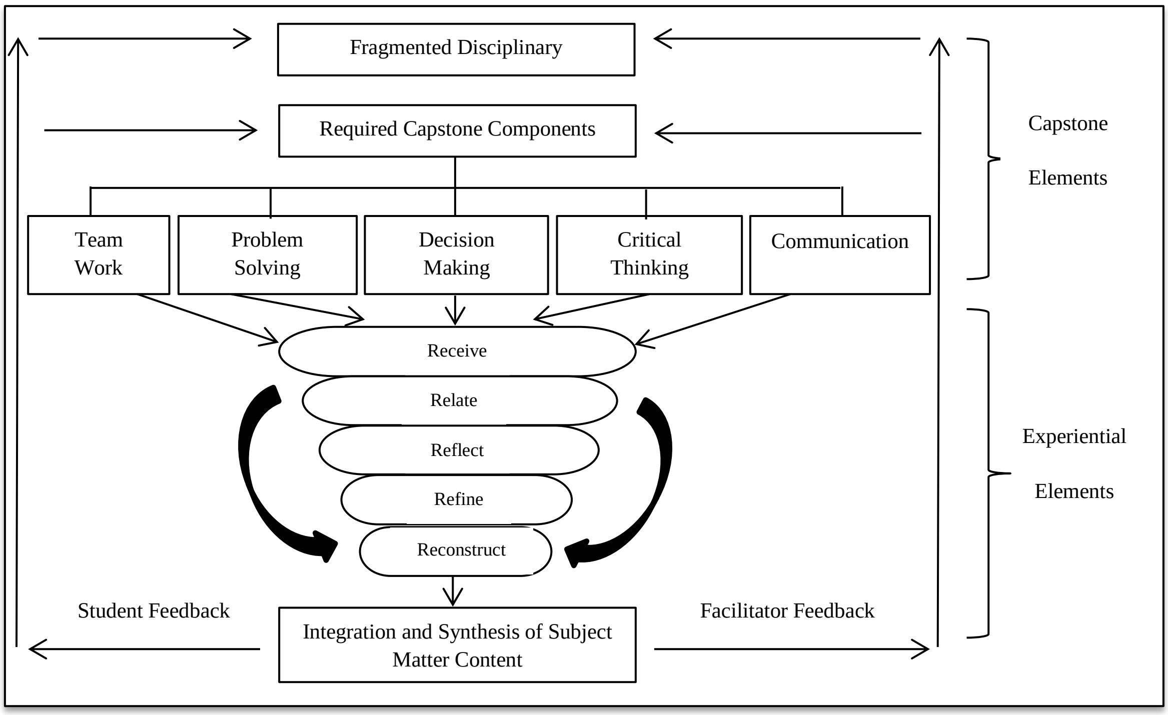

Figure 6.1. From "Integrating experiential learning into college of agriculture capstone courses: implications and applications for practitioners," by R. J. Andreasen, 2004. Reprinted with permission.

The next section of the MIELLCC integrates several major theories of experiential learning, where receiving, relating, reflecting, refining and reconstructing information (the five R's) act as a funnel to synthesize content (Andreasen, 1998). The first R, receiving, 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, relating, is concerned with linking learned experiences to previously gained knowledge to better integrate experiential learning into the 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).

Reflection occurs when students purposefully reflect upon experiences received and begin to relate them to other scenarios (Andreasen, 1998). Experiential learning becomes distinguishable from learning through experiences in the reflection and relationship of experiences (Andreasen, 1998). The refine stage is characterized by a process where students contemplate the applicability of newly attained knowledge and its association to previously attained knowledge (Andreasen, 1998). This stage is associated with abstract conceptualization (Kolb, 1984) and generalize (CSREES, 1992) stages of other experiential learning models.

The final R, reconstruction, allows for synthesis of content so it can be integrated into useable knowledge and applied to different situations or practices (Andreasen, 1998). The Lewinian (1951) model associates this stage with testing implications of new concepts in new situations. The CSREES (1992) model associates this stage with applying newly attained knowledge to a similar or different situation. The MIELLCC concludes in a cyclical manner—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 again.

Problem Statement

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). A popular method of increasing students' critical thinking abilities is through active learning (Duron et al., 2006; Popil, 2011; Tsui, 2002; Yang, 2012; Youngblood & Beitz, 2001). Capstone courses are an example where active learning often takes place. In addition, capstone courses, based on experiential learning models, are meant to target students' critical thinking abilities (Crunkilton et al., 1997; Kranz, 1991). However, the question becomes whether or not an experiential learning-based capstone course does positively influence the critical thinking abilities of students.

Purpose and Objectives

As part of a larger investigation, the purpose of this study was to explore the impact a semester-long capstone farm management course had on the development of undergraduate agriculture students' critical thinking abilities. 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). The objectives of the study were to:

1. Identify the demographic and academic characteristics of students enrolled in a capstone farm management course.

2. Determine if there were significant changes in the critical thinking abilities of students enrolled in the capstone farm management course over a period of one semester.
3. Compare the capstone farm management course students' critical thinking abilities to national norm data.

Methods and Procedures

Class Structure

The capstone course examined in this study provided graduating seniors in a production agriculture major the opportunity to gain working knowledge or training in at least four content areas: (1) farm practices, (2) scientific principles of crop and animal production, including the use of power and equipment, (3) business principles of farming, and (4) making management decisions (Murray, 1945). Although the initial concept of the course remains intact, the operational enterprises and course structure have changed drastically. Students enrolled in the course are in charge of day-to-day managerial decisions and operational tasks associated with operating a self-sustaining row crop enterprise and a swine finishing operation. Decisions are made and achieved by the students through structured business meetings (Andreasen, 1998). The course is further broken into two laboratory sections, each meeting separately once a week at the farm for four hours.

This capstone course allowed students the opportunity to apply prior technical content knowledge and skills of production and 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 the capstone course included 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.

Participants

All undergraduate students enrolled (N = 54) in the capstone farm management course during the spring 2013 semester were considered the population for this study. Of the paired tests administered to the students in the capstone course (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) determined a minimum of ten matched pairs sufficient in evaluating changes in critical thinking abilities through a pre-test/post-test design, available resources allowed for fifteen additional (n = 25) paired assessments randomly selected and scored for this study. This group was purposively selected in an attempt to examine potential gains in critical thinking abilities through enrollment and participation in a culminating capstone course experience.

Instrument

Due to utilization of open-ended responses, as well as national reference norms, critical thinking abilities were assessed using the Critical Thinking Assessment Test (CAT). The CAT is a National Science Foundation supported tool created to assess and improve critical thinking skills (CAIL, 2012). The CAT included fifteen short-answer questions, based on real world situations developed by university faculty across the nation to accurately assess important components of critical thinking (CAIL, 2010). Each question was representative of an independent skill area. Under direct supervision of CAIL-trained individuals, the participating institution's faculty completed scoring of the CAT assessments. Detailed scoring rubrics provided by CAIL were utilized to enhance consistency and reliability in evaluations. Among other uses, the CAT instrument has been designed to evaluate the effects of a specific course through a pre-test/post-test design (CAIL, 2012). The fifteen specific skill areas assessed by the CAT instrument (Figure 6.2) 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 6.2. 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. 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 calculated 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.

Procedure

A pre-post design was utilized for this study. Several studies have utilized a pre-test/post-test design to evaluate the effects an educational experience has on the development of students’ critical thinking abilities (Bers, McGowen, & Rubin, 1996; Friedel et al., 2008; Iwaoka, Li, & Rhee, 2010). Furthermore, the CAT is an appropriate instrument for pre-test/post-test designs, since it possesses a test-retest reliability coefficient greater than .80 (CAIL, 2010). The pre-tests and post-tests utilized for this study were administered separately in each of the two laboratory sections of the course during weeks one and 15 of the 16-week, spring 2013 semester. For data reporting purposes, demographic and academic characteristics of all students (N = 54) enrolled in the capstone course were compared by laboratory section. A Pearson’s χ^2 analysis yielded no significant difference ($p > .05$) 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, this study's results are displayed and discussed in relation to the entire capstone course as opposed to the individual laboratory sections.

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 was defined as the sum of all credit hours taken at the current university and any credit hours that may have been transferred from another institution.

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). Typical to educational research, statistical significance was set a-priori at $p < .05$ (Gall et al., 1996). For objective two, paired sample *t*-tests were utilized to determine if enrollment in a capstone farm management course for a single semester made a statistical difference ($p < .05$) in students' critical thinking abilities. A one sample *t*-test utilizing CAT national norm data collected from junior and senior level higher education students across the nation was conducted to address objective three. Participants' post-test scores were utilized for this comparison to take into account any effects of enrollment in the capstone course. 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 is was large.

Data were representative of a homogenous sample in regards to educational degree pursuit. Therefore, care should be used when extrapolating beyond those students enrolled in the capstone course. However, the data offer insight for other institutions regarding factors influencing the critical thinking abilities of undergraduate students.

Results

The first research objective sought to describe the demographic and academic characteristics of participants enrolled in the capstone farm management course. Participants were 76.0% (n = 19) male and 24.0% (n = 6) female. All participants (n = 25) were between the ages of 21 and 25. All participants (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 number 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 for those reporting was 21.07 (SD = 3.01).

Objective two sought to determine if there were significant changes in the critical thinking and problem solving abilities of students enrolled in the capstone farm management course over a period of one semester. Multiple paired sampled *t*-tests were conducted to compare pre-course and post-course critical thinking and problem solving abilities according to the fifteen specific skill areas assessed by the CAT (Table 6.1). Possessing a moderate effect size (d = 0.44), the only skill area that demonstrated a statistically significant difference ($p < .05$) between the pre-test and post-test score was participants' abilities to summarize the pattern of results in a graph without making inappropriate inferences. Although not statistically significant at the specified level ($p >$ .05), eight of the fifteen skill areas assessed displayed a higher post-test score than pre-test score.

The purpose of objective three was to explore differences among the post-test scores of the capstone farm management course students' critical thinking abilities and CAT national norm data (Table 6.2). The only skill area where participants scored significantly higher ($p < .05$) than CAT national norm data was the ability to separate relevant from irrelevant information when solving a real-world problem. This difference in skill area ability possessed a moderate effect size (d = 0.47). Participants scored statistically lower ($p < .05$) than CAT national norm data in the skill areas of identifying additional information needed to evaluate a hypothesis and providing relevant alternative interpretations for a specific set of results. Both possessed large effect sizes (d = 1.14, 0.68), respectively. Participants scored significantly lower ($p < .05$, d = 0.50) than the CAT national norm data in regards to overall CAT score.

Table 6.1

Results of Paired Samples t-Test of Participants Enrolled in a Capstone Farm Management Course (n = 25)

	Pre-test			Post-test							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
Summarize 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											

Table 6.1 Continued

problem using relevant info.	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.	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

Note. [a] = average percent of attainable points per skill area; [b] = institutional minus national; [c] = probability of difference; [d] = mean difference divided by pooled group *SD* (0.1 – 0.3 = small; 0.3 – 0.5 = moderate; > 0.5 = large); * = significant at $p < .05$.

Table 6.2

Results of t-Test of Participants Enrolled in a Capstone Farm Management Course as Compared to National Norm Data (n = 25)

	Post-test			National							Effect
Skill Area Assessed	*M*	*SD*	%[a]	*M*	*SD*	%[a]	Diff.[b]	*t*	*df*	*p*[c]	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.	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

Table 6.2 Continued

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 info.	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

Note. [a] = average percent of attainable points per skill area; [b] = institutional minus national; [c] = probability of difference; [d] = mean difference divided by pooled group *SD* (0.1 – 0.3 = small; 0.3 – 0.5 = moderate; > 0.5 = large); * = significant at $p < .05$.

Conclusions and Discussion

This study sought to contribute to the literature investigating the influences of semester-long capstone courses on the development of students' critical thinking abilities, specifically, to determine if there were significant changes in the critical thinking abilities of students enrolled in a semester-long capstone farm management course. Reflective of the critical thinking abilities identified by Pascarella and Terenzini (1991), the primary conclusion of this study is enrollment in a semester-long capstone farm management course can positively influence students' abilities to recognize important relationships and make correct inferences from data.

The researchers conclude enrollment in the capstone farm management course does not improve students' overall critical thinking ability. No statistically significant changes were evident between the overall pre-/post-test scores. These findings align with previous research where no significant differences were found among overall critical thinking pre-/post-test scores of a semester-long course (Iwaoka et al., 2010). 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 remains a complex concept not easily assessed by a singular instrument. Perhaps the capstone course facilitated 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 the capstone farm management course does not improve overall critical thinking ability, the researchers conclude enrollment may place emphasis on certain aspects of critical thinking development, while negating to address others. More specifically, enrollment in the capstone farm management course reinforces students' abilities to separate relevant from irrelevant information. This conclusion is reassuring, since, according to Andresen's (1998) MIELCC, receiving information and solving problems are integral elements of experiential learning and capstone courses When comparing the capstone farm management course students' critical thinking abilities to national CAT norm data, findings indicated students possessed statistically significantly higher scores than the national norms in their ability to separate relevant from irrelevant information when solving real-world problems. However, participants performed statistically below the national norms in regards 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 should be mentioned the CAT national norms are comprised of students from colleges across the nation representing a multitude of academic majors. 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). It should also be mentioned in all but two cases, separating relevant from irrelevant information and using basic mathematical skills to solve a problem, participants' pre-test scores were already below the CAT national norms. Exceptional increases in critical thinking ability would have been required to advance the post-test scores above the CAT national norms.

The capstone farm management course in this study utilized numerous instructional approaches to accomplish its intended learning outcomes, where critical thinking is pivotal. The specific approaches directed toward enhancing the critical thinking abilities of the students enrolled in the capstone course included, but not limited, to student discussions (Tsui, 2002; Yang, 2012), written (Tsui, 2002) and oral communication (Wagner, 2008), and issues analysis (Pascarella & Terenzini, 1991). Since these approaches align with the Crunkilton et al.'s (1997) required learning activities of a capstone course, increases in overall critical thinking abilities were anticipated. Andreasen's (1998) MIELCC incorporated these learning activities and implied students in capstone courses must utilize critical thinking, decision-making, problem solving, and communications to create new ideas that integrate and synthesize subject matter content. Therefore, it could be argued that achieving the outcomes of a capstone course is not solely represented in the form of increases in overall critical thinking ability, but could also be represented in increases in decision-making, problem solving, and communication abilities. Since the CAT is a short-answer formatted assessment, written communication abilities influence a significant portion of students' measured critical thinking and problem solving abilities.

A capstone course should be viewed as a complex system that utilizes multiple instructional frameworks to move students toward the construction of new knowledge. Thus, increases in any skill area associated with overall critical thinking abilities would speak to outcomes attainment from the course. Crunkilton et al. (1997) identified teamwork, problem solving, critical thinking, communications, and decision-making as intended outcomes of capstone courses. If overall critical thinking abilities are not increasing over the span of one semester, are capstone courses, such as the one in this study, actually achieving the intended outcomes identified by Crunkilton et al. (1997)? Acknowledging the CAT instrument does not assess teamwork, are there other, broader outcomes achieved, but not measured, in this study? More importantly, are capstone course instructors creating curricula that target multiple intended outcomes or has the focus shifted to a more content specific outcome? What can instructors do to assist their students to develop critical thinking abilities in these settings?

Implications and Recommendations

Conclusions from this study possess implications for professional development, curriculum development, and academic research. Since enrollment in the semester-long capstone farm management course did not significantly affect students' overall critical thinking abilities, capstone course instructors teaching similar courses to the one described in this study should take the time to critically analyze and evaluate personal teaching methods and approaches to ensure critical thinking learning outcomes are being addressed. Capstone farm management course instructors working to increase critical thinking abilities of students 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).

To attain a comprehensive understanding of critical thinking required to create the appropriate curricula, capstone farm management course instructors should attend professional development opportunities that specifically address teaching strategies for integrating and overtly teaching critical thinking. More specifically, these instructors should be intentional in the creation and utilization of 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 the conclusions the capstone farm management course in this study placed emphasis on certain aspects of critical thinking development, while negating to address others. Therefore, capstone farm management course curriculum should be reviewed to ensure it is explicitly includes activities directly targeting a diversified array of critical thinking abilities, as well as affective dispositions, since affective dispositions enable students to address situations that require higher-ordered thinking (Facione, 1990).

Implications for research emerge from the conclusion that enrollment in the semester-long capstone farm management course did not significantly affect students' overall critical thinking abilities. Agricultural education research should expand on this study to determine effective means of increasing students' critical thinking abilities in capstone farm management courses. However, a close examination of the timing of both the pre-test and post-test should be conducted before replication. An apparent lack of student motivation and effort may have been present in the post-test. The post-test was administered during the second to last week of the course, which was the last semester of college for many of the students enrolled in the course. The excitement and anxiety of nearing graduation dates might have affected the students' willingness to perform on the post-test, especially since performance on the test carried no consequence on overall course grade (Wolf & Smith, 1995).

In this study, the examined capstone farm management course provides a unique opportunity for experimental design research in that it is separated into two laboratory sections. Altering instructional approaches, while utilizing a control group, could provide more insight in determining effective strategies for capstone farm management courses. Altering assessment instruments in a similar design could provide a more holistic view of what specific critical thinking skill areas are being developed in a capstone course, regardless of discipline. A multi-year, longitudinal study conducted by capstone farm management course instructors could provide a means of tracking these instructional alterations and the associated student learning effects.

Qualitative research exploring how agricultural education students view critical thinking is also recommended. Do today's agricultural education students value the skills associated with critical thinking? If, in fact, they value these critical thinking skills, do they demonstrate greater increases in critical thinking development than those who do not? Since critical thinking is a complex system, other factors affecting the development of critical thinking should be researched. How influential are students' past experiences on the development of critical thinking skills? How can instructors utilize students' past experiences in the capstone course framework to facilitate critical thinking? Faculty needs to consider these recommendations for professional development, curriculum development, and research to advance the critical thinking area of study.

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CHAPTER VII. GENERAL CONCLUSIONS AND RECOMMENDATIONS

The purpose of this study was to describe the current critical thinking abilities of undergraduate agriculture education and studies students, and to explore how entry pathway and enrollment in a capstone course affect these abilities. The first paper, Chapter four, utilized a random sample of all senior-level undergraduates within the Department of Agricultural Education and Studies (AgEdS) at Iowa State University (ISU) to establish a benchmark for critical thinking ability. The second paper, Chapter five, utilized the same random sample to determine if entry pathway, direct from high school admittance versus transfer from community college admittance, had an effect on critical thinking abilities of agricultural education and studies students. The final paper, Chapter six, explored the impact a semester-long capstone farm management course had on the development of undergraduate agricultural education and studies students' critical thinking abilities. Chapter 7 examines the general conclusions and recommendations for both practice and research. The conclusions and recommendations are organized into two broad categories: (1) a benchmark for the Department of AgEdS and (2) factors affecting critical thinking ability.

A Benchmark for The Department of AgEdS

Recognizing limited available research examining the critical thinking abilities of students in colleges of agriculture (Rudd, Baker, & Hoover, 2000), a portion of this dissertation was dedicated to establishing a benchmark for the critical thinking abilities of graduating seniors enrolled within the Department of AgEdS. The assessment instrument utilized to establish this departmental benchmark, The Critical Thinking Assessment Test (CAT), contained fifteen specific skill areas further grouped into four overlapping broad categories according to question topic: (1) creative thinking, (2) problem solving, (3) evaluate and interpret information, and (4) effective communication.

Students performed greatest in the evaluate and interpret information domain of the CAT, scoring at CAT upper-level undergraduate student national norm data on six out of the eight questions representing abilities to evaluate and interpret information and above national norm data on one. Students' problem solving abilities were the second greatest with average scores meeting national norm data on five of the eight problem solving questions. Similar to other research (Rudd et al., 2000), effective communication appeared difficult for students, since average communication domain scores were statistically below national norm data on four of the nine questions addressing effective communication. Further, students performed poorly when it came to the creative thinking domain. Average scores were statistically below national norms on four of the six questions pertaining to creative thinking.

Although students' current critical thinking abilities founded in evaluation, interpretation, and problem solving may seem more developed than those founded in communication and creative thinking, care should be taken when interpreting these data, since performance in each domain relies on students' abilities to effectively communicate their thought progressions in a manner interpretable by an outside evaluator. The CAT's reliance on written communication abilities revealed an area of improvement for students in the Department of AgEdS. Since writing is a systematic process that forces students to arrange their thoughts and make them accessible to others (Willsen, 1995), writing and re-writing aid in the development of critical thinking skills (Tsui, 2002).

Therefore, recommendations for practice within agricultural education include creating activities that focus on developing students' written communication abilities and determining learning objectives that facilitate effective communications and creative thinking. This does not mean abandon current approaches demonstrating positive influences on students' abilities to evaluate and interpret information and solve problems. Rather, a more comprehensive approach is recommended. The ability to create pedagogical approaches and specific learning activities that cultivate critical thinking requires an extensive understanding of various critical thinking components. Thus, the Department of AgEdS faculty should participate in professional development opportunities to learn more about the process of teaching critical thinking. Faculty should also consider mapping the curriculum for each major within the Department of AgEdS to identify the critical thinking domains of most importance. Curriculum development and learning outcomes should then begin to mirror the identified domains.

Recommendations for research stemming from the establishment of this critical thinking benchmark include exploring differences in critical thinking ability according to academic major/option in a department of agricultural education, and conducting longitudinal studies at the departmental or collegiate level to explore the development of students' critical thinking abilities throughout the course of their higher education experience. This study did not explore the effects academic major/option had on students' critical thinking abilities. Further, this study did not examine courses taken outside AgEdS. Future research conducted in agricultural education should take an extensive look at the influences a single course, offered both inside and outside the department studied, may have on the development of students' critical thinking abilities.

Agricultural education research should also explore the more complex components affecting critical thinking skills and development, such as affective disposition. Critical thinkers possess a set of affective dispositions that enable them to address situations requiring higher-ordered thinking (Facione, 1990). Although a person can have the cognitive skills to think critically, they are more effective thinkers if they exhibit these affective dispositions (Rudd, 2007). Recommendations for research surrounding the relationship between student motivation and critical thinking assessment performance emerged, due to anecdotal observations pertaining to the timing of the CAT. The CAT was administered during the last couple of weeks of the semester. For many of students, it was also the last couple of weeks of their college career. Future studies replicating methods similar to this study should consider the timing of assessment delivery.

Factors Affecting Critical Thinking Ability

Critical thinking abilities are a result of critical thinking dispositions and a set of facilitating factors, which include demographics, academic performance, experience, and training (Ricketts & Rudd, 2005). This study did not explore critical thinking dispositions, but it did explore each of the remaining facilitating factors. It was concluded gender was not a predictor of critical thinking ability. This conclusion aligns with Brahmasrene and Whitten (2011), Burbach, Matkin, and Quinn (2012), and Friedel, Irani, Rhoades, Fuhrman, and Gallo’s (2008) research. However, it is at odds with the findings by King, Wood, and Mines (1990), Bers, McGowen, and Rubin (1996), and Jacobs (1995). The verdict is seemingly still out on the role of gender in predicting critical thinking ability. Future studies should continue to explore the role of gender in critical thinking ability.

Similar to previous research by Burbach et al. (2012), Friedel, Irani, Rhoades et al. (2008), and Ricketts and Rudd (2005), academic performance remained a consistent predicator of critical thinking ability. Students' ACT scores were the only significant predictor of overall critical thinking ability in this study. This finding also mirrored 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 indicates students' scores on the CAT instrument correlate with a significance of $p < 0.01$ with their scores on the ACT ($r = 0.501$) and SAT ($r = 0.516$). Future agricultural education studies should continue to explore academic predictors of critical thinking, as well as begin to explore potential relationships between standardized collegiate entrance exams and critical thinking assessment instruments.

Educational experience was a facilitating factor of critical thinking as well. Although no statistical differences were represented in the overall critical thinking abilities of students according to entry pathway, differences were evident within each of the domains assessed by the CAT: (1) creative thinking, (2) problem solving, (3) evaluate and interpret information, and (4) effective communication. Specifically, agricultural education and studies transfer students within the Department of AgEdS exhibited a greater ability to think creatively than those who entered directly from high school. Few studies have examined the effects of entry pathway on critical thinking ability. Jacobs (1995) compared the critical thinking dispositions of community college students to those of entering freshmen at a private university (Facione, Sanchez, Facione, & Gainen, 1994). Findings indicated the community college group possessed weaker dispositions to think critically than the incoming freshmen of the private university. Future studies should explore critical thinking abilities of transfer students at the time of transfer as well as at the time of graduation. Are critical thinking gains of agricultural education transfer students similar to those of traditional pathway students?

For this study, training was represented in the form of enrollment in a semester-long capstone farm management course and was not found a strong facilitating factor of critical thinking ability. No significant changes were found in the overall critical thinking abilities of students enrolled in the semester-long capstone farm management course. Critical thinking is a fundamental aspect of the course reinforced through course activities. Conclusions of this study add to the debate as to whether critical thinking should be addressed within the context of subject matter instruction or as a general entity (Kuhn, 1999). Burbach et al. (2012) suggested instructors integrate critical thinking pedagogies into courses, and overtly teach critical thinking skills and dispositions. However, conclusions of this study suggest addressing critical thinking as a general entity would be worth attempting, since the capstone farm management course did not have substantial influences on the development of students' critical thinking abilities.

The primary recommendation for agricultural education practice includes faculty analysis and evaluation of personal teaching methods and approaches to ensure critical thinking learning outcomes are addressed. Agricultural education curriculum should also be reviewed to ensure it explicitly includes activities directly targeting a diversified array of skill areas associated with improving critical thinking abilities. Instructors working to increase the critical thinking abilities of agricultural education students should be intentional in targeting the development of these abilities. Additionally, agricultural education departments should consider the creation of a critical thinking course to address critical thinking as its own entity.

Recommendations for research include a thorough exploration of differences in critical thinking abilities, according to the specific domains of critical thinking and the examination of agricultural education curricular differences between the first two years of community college and the first two years at a four-year university. Specifically, a closer look at the abilities measured by the assessment tool utilized in this dissertation is recommended to ensure alignment with educational outcomes identified by the Department of AgEdS. Longitudinal studies, conducted at either the departmental or collegiate level, tracking critical thinking development over the span of a four-year degree are recommended. Further, the AgEdS 450 course provides a unique opportunity for experimental design research—it is separated into two laboratory sections. Altering instructional approaches in the capstone farm management course, while utilizing a control group, could provide more insight in determining effective strategies for capstone courses. Another longitudinal study conducted by capstone farm management instructors could provide a means of tracking these instructional alterations and the associated student learning effects.

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APPENDIX A. INSTITUTIONAL REVIEW BOARD APPROVAL LETTER

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

Institutional Review Board
Office for Responsible Research
Vice President for Research
1138 Pearson Hall
Ames, Iowa 50011-2207
515 294-4566
FAX 515 294-4267

Date: 1/15/2013

To: Dr. Dustin Perry
201 Curtiss Hall

CC: Dr. Michael Retallick
206 Curtiss Hall
Dr. Thomas H Paulsen
217 Curtiss Hall

From: Office for Responsible Research

Title: Evaluating Critical Thinking Abilities of Graduating Post-Secondary Seniors

IRB ID: 12-644

Study Review Date: 1/15/2013

The project referenced above has been declared exempt from the requirements of the human subject protections regulations as described in 45 CFR 46.101(b) because it meets the following federal requirements for exemption:

- (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey or interview procedures with adults or observation of public behavior where
  - Information obtained is recorded in such a manner that human subjects cannot be identified directly or through identifiers linked to the subjects; or
  - Any disclosure of the human subjects' responses outside the research could not reasonably place the subject at risk of criminal or civil liability or be damaging to their financial standing, employability, or reputation.

- (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens if these sources are publicly available or if the information is recorded by the investigator in such a manner that subjects cannot be identified directly or through identifiers linked to the subjects.

The determination of exemption means that:

- **You do not need to submit an application for annual continuing review.**
- **You must carry out the research as described in the IRB application.** Review by IRB staff is required prior to implementing modifications that may change the exempt status of the research. In general, review is required for any modifications to the research procedures (e.g., method of data collection, nature or scope of information to be collected, changes in confidentiality measures, etc.), modifications that result in the inclusion of participants from vulnerable populations, and/or any change that may increase the risk or discomfort to participants. Changes to key personnel must also be approved. The purpose of review is to determine if the project still meets the federal criteria for exemption.

  Non-exempt research is subject to many regulatory requirements that must be addressed prior to implementation of the study. Conducting non-exempt research without IRB review and approval may constitute non-compliance with federal regulations and/or academic misconduct according to ISU policy.

  Detailed information about requirements for submission of modifications can be found on the Exempt Study Modification Form. A Personnel Change Form may be submitted when the only modification involves changes in study staff. If it is determined that exemption is no longer warranted, then an Application for Approval of Research Involving Humans Form will need to be submitted and approved before proceeding with data collection.

Please note that you must submit all research involving human participants for review. **Only the IRB or designees may make the determination of exemption**, even if you conduct a study in the future that is exactly like this study.

APPENDIX B. STUDY INTRODUCTION, INVITATION, AND FOLLOW-UP EMAILS

Pre-notice Email Message to Potential Participants

Hello NAME,

We have contacted you to ask for your assistance with an important study being conducted exploring the critical thinking and problem-solving abilities of seniors within the ***Department of Agricultural Education and Studies*** at Iowa State University. In the next day you will receive an email requesting your participation in this project by completing a one hour assessment designed to evaluate critical thinking and problem-solving abilities.

We would like to do everything we can to make it easy and enjoyable for you to participate in the study. We have contacted you in advance because we understand that many students prefer to be notified ahead of time that they will be asked to participate in such a project. We also understand that you more than likely have been solicited numerous times to participate in university research. However, we hope that you take particular care in considering participating in this study as it will directly affect your department. This research can only be successful with the generous help from students like you.

To show our appreciation, we will provide lunch for you before you participate in the assessment. We genuinely hope that you will be able to assist us. Most of all, we hope that you enjoy the assessment as well as the opportunity to voice your thoughts and opinions about the importance of such a project.

Best Wishes,

Dustin Perry
Graduate Assistant
Agricultural Education & Studies
Iowa State University
223 Curtis Hall
Ames, IA 50011
Voice: 214-454-2399

Michael S. Retallick, Ph.D.
Associate Professor
Agricultural Education and Studies
Iowa State University
206 Curtiss Hall
Ames, IA 50011-1050
Voice: 515-294-4810

Thomas H. Paulsen, Ph.D.
Assistant Professor
Agricultural Education & Studies
Iowa State University
217C Curtiss Hall
Ames, IA 50011
Voice: 515-294-0047

Email Message Requesting Participation

Good Morning NAME,

Hopefully your final semester has begun smoothly. The college experience can be an excellent opportunity for individuals to focus on and develop their critical thinking and problem-solving abilities. Thus, Dr. Thomas Paulsen, Dr. Michael Retallick and I would like your assistance in exploring critical thinking and problem-solving abilities of graduating seniors within the ***Department of Agricultural Education and Studies***. Your involvement would consist of participating in a one hour exam at the beginning of this Spring semester. The exam, The Critical Thinking Assessment Test (CAT), is comprised of 15 open-ended questions that explore your critical thinking and problem-solving thought processes. Because we are only studying your thought processes, there are not right or wrong answers to these questions.

This project has been approved by the Institutional Review Board (IRB) at Iowa State University. Your participation in this project is voluntary and in no way will affect your grade or standing. Your score and identity will be kept confidential and be known only to us. Furthermore, scoring and analyses will not be conducted until final Spring grades have been posted. With your assistance, we have a great opportunity to begin a thoughtful reflection of critical thinking as it pertains to the college experience.

Please reply to this email and indicate whether or not you are willing to participate. For those agreeing to participate, we would like to begin coordinating initial testing times as soon as possible. Thank you for your consideration in assisting us with this project. We look forward to hearing from you.

Sincerely,

Dustin Perry
Graduate Assistant
Agricultural Education & Studies
Iowa State University
223 Curtis Hall
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Michael S. Retallick, Ph.D.
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Thomas H. Paulsen, Ph.D.
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Reminder Email to Non-Respondents

Dear NAME,

Last week you should have received an email requesting your assistance in evaluating how well the ***Department of Agricultural Education and Studies*** is addressing the important issue of developing undergraduate students' abilities to think critically and solve problems. The best way we have of learning about this issue is by asking seniors within the department to take an assessment specifically designed to explore their critical thinking and problem solving abilities. Your name is one of only a small number that have been randomly selected to help in this study. We are attempting to contact you again because we truly need your help in making this project a success.

Your involvement would consist of taking a one hour exam (**lunch will be provided**) at a time and date convenient to you. The exam, The Critical Thinking Assessment Test (CAT), is comprised of 15 open-ended questions that explore your critical thinking and problem-solving thought processes. Because we are only studying your thought processes, there are not right or wrong answers to these questions.

This project has been approved by the Institutional Review Board (IRB) at Iowa State University. Your participation in this project is voluntary and in no way will affect your grade or standing. Your score and identity will be kept confidential and be known only to us. Furthermore, scoring and analyses will not be conducted until final Spring grades have been posted. With your assistance, we have a great opportunity to begin a thoughtful reflection of critical thinking as it pertains to the college experience.

By taking an hour of your time to complete this exam you will be helping us out a great deal, and as a small token of appreciation we will provide lunch as a way of saying thank you. **Please reply** to this email and indicate whether or not you are willing to participate. For those agreeing to participate, we would like to begin coordinating initial testing times as soon as possible.

Thank you for again your consideration in assisting us with this project. We look forward to hearing from you.

Many Thanks,

Dustin Perry
Graduate Assistant
Agricultural Education & Studies
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223 Curtis Hall
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APPENDIX C. PERMISSIONS TO REPRINT MODEL FOR THE INTEGRATION OF EXPERIENTIAL LEARNING INTO CAPSTONE COURSES

From: Dustin Perry [mailto:dkperry@iastate.edu]
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Title: Integrating experiential learning into college of agriculture capstone courses: Implications and applications for practitioners
Authors: Andreasen, R. J.
Date: 2004
Journal Information: North American Colleges and Teachers of Agriculture, 48(1), 52-57.

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Dustin Perry

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Rick
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NACTA Journal Editor
Ph: 208-670-3704
Fax: 208 -436-1384
E-mail: nactaeditor@pmt.org
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A Developmental Model of Critical Thinking
Author(s): Deanna Kuhn
Source: Educational Researcher, Vol. 28, No. 2 (Mar., 1999), pp. 16-25+46
Published by: American Educational Research Association
Stable URL: http://www.jstor.org/stable/1177186 .

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