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STUDIES ON CRITICAL THINKING FOR ENVIRONMENTAL ETHICS

by

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A DISSERTATION

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STUDIES ON CRITICAL THINKING FOR ENVIRONMENTAL ETHICS

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University of Nebraska, 2012

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This study examined the role of critical thinking in regards to environmental ethical issues. First, an instrument was developed and validated to quantitatively measure students' ability to apply critical thinking skills to various environmental ethical issues. Next, the instrument and a qualitative assessment were used to examine critical thinking capabilities of freshmen upon entry to a large introductory course. Last, the Environmental Ethics Critical Thinking Assessment, in conjunction with the qualitative assessment, were used to examine the change in critical thinking ability of all students in a large introductory course from pre to post-semester. In both studies, numerous antecedents to critical thinking were examined including critical thinking disposition, age, major, gender, previous courses taken on related subjects, self-rated strength of views, and self-rated leadership. Overall, students exhibited low levels of critical thinking. Both studies found gender and critical thinking disposition significant predictors of critical thinking skills. Qualitative analysis indicates that students improved their use of summarizing an author's ideas in their own words, providing an example to help explain, comparing and contrasting diverging ideas, analyzing the structure of an argument, deriving plausible conclusions, discussing possible consequences, giving reasons to accept a claim, reflecting upon their own thinking, and identifying personal biases. However, all improvements were minimal and a large majority of students did not improve their use of critical thinking skills on a written assignment from pre to post-semester.

This work is dedicated to my daughter, Abbey Wren Quinn.
Remember, “Freedom begins between the ears.” – Edward Abbey

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CHAPTER I

Introduction

The environmental, social, and economic problems of the 21st century can seem daunting. The burning of fossil fuels has increased greenhouse gas concentrations in our atmosphere, contributing to changes in our planet's climate that brings unknown consequences for human and natural communities (IPCC, 2007). The current rate of species extinction is estimated at 100 to 1,000 times more than what is considered natural and has likely surpassed a planetary boundary in which species provide ecosystem resilience (Rockstrom et al., 2009). Despite the above challenges of climate change and species loss, agriculture will need to feed 9 billion people using less land while providing greater environmental protection (Foley et al., 2011). In addition, the disparity between the rich and poor is increasing and many people continue to live in poverty (US Census, 2012), which in turn exacerbates environmental problems. Ferdig (2009) sums up the challenges we face, noting three interrelated areas requiring our attention; 1) the long-term viability of natural systems, 2) the unacceptable social conditions around the world, and 3) creating local and global economies that provide wealth and prosperity for all. The role of environmental professionals is to help society rise to meet these challenges.

Environmental issues bring many questions and few clear solutions. Yet, as difficult as it is to understand and predict change in atmospheric CO₂ and possible effects, or to calculate the number of species and rate of extinction, even more difficult challenges and questions emerge. Ethical problems continually arise for individuals, agencies, and governments. For example, whose responsibility is it to reduce greenhouse

gases; developing or developed countries? Do citizens in developed countries who currently consume resources at a much greater rate than people in developing countries have an obligation to reduce consumption to more sustainable levels? Is it ethical to utilize biofuel for vehicles when it could be used for human or animal food? What makes these questions especially challenging is the variety of answers to each problem and the vehement disagreements that occur between stakeholders.

None of these questions has easy answers. However, our obligation to address such pressing concerns is undeniable. Perhaps another question we must ask is, *who* will help us navigate the contentious waters of ethical debates regarding such difficult issues. Who will help society debate, make decisions, and act to sustainably manage our natural resources and care for living communities? Given such pressing problems, the time for leadership in the environmental community has never been greater. Past leaders, such as John Muir, Rachel Carson, and Aldo Leopold effectively influenced society's thinking on such issues as land preservation and use of pesticides. However, today's environmental problems are more pervasive, varied, and global in scope. Environmental ethical questions link to seemingly disparate issues of social justice, animal welfare, and future generations. As David Orr states, we need

leaders who see patterns that connect us across the divisions of culture, religion, geography, and time. We need leadership that draws us together to resolve conflicts, move quickly from fossil fuels to solar power, reverse global environmental deterioration, and empower us to provide shelter, food, medical care, decent livelihood, and education for everyone. We need leadership that is capable of energizing genuine commitment to old and venerable traditions as well as new visions for a global civilization that preserves and honors local cultures, economies, and knowledge.

Leadership will be critical for society to mitigate and adapt to environmental challenges and to steer society through the tumultuous task of facing ethical problems. Scholars have discussed what attributes, behaviors, and skills environmental leaders need to be effective. Orr (2003) writes, leaders must be “of great stature, clarity of mind, spiritual depth, courage, and vision.” At the same time, Orr adds, they must be humble. To this list others add intelligent, articulate, charismatic, media-savvy, strong, dedicated, and focused (Joly, 2004; Lindenmayer & Likens, 2010).

To this list, I add that critical thinking is necessary. The ability to think critically about the ethical ramifications of our actions towards the environment will be a crucial skill of any environmental leader in the 21st century. The problems we face are complex, and we cannot examine them in rigid ‘silos’, as each problem affects the other. Consider the ethical issues surrounding food production and consumption; fossil fuel use and climate change, urbanization, pesticide use and pollution, species loss, animal rights and welfare, the disappearance of family farms, the role of corporations and patent rights, poverty and hunger, obesity, gender issues, the cost of health care, international trade, and indigenous rights, to name a few. It is not enough for an environmental leader to say, “We must feed 9 billion people” or “We should produce food as close to home as possible”. A leader must have the ability to examine an issue and see all of the connecting threads, how each issue is intertwined with others. In turn, a leader must be able to explain this complexity to others to facilitate problem solving with various stakeholders. Critical thinking skills will allow leaders to work in complex environmental and human systems.

Leaders lacking the skill of critical thinking will be less effective and make mistakes that are difficult to overcome (Flores, Matkin, Burbach, Quinn, & Harding, 2011). In addition, omitting the role of critical thinking in regards to ethical implications of environmental, natural resources, and agricultural issues is dangerous because professionals in these fields make decisions that have profound economic, social, and ecological consequences (Jones & Merritt, 1999). Given the enormity of our environmental and social situation, costly divergences and narrow-minded thinking are not an option.

To ensure environmental leaders have critical thinking skills employers are increasingly demanding (AACU, 2009; Arum & Roska, 2011) that recent graduates arrive ready for work with the ability to think critically. In turn, universities are calling on instructors to help students develop their desire and ability to apply critical thinking skills. Examine almost any college or university's promotional materials and you will find mention of developing critical thinking skills in students.

The chapters presented here are an investigation into critical thinking development for students in higher education regarding environmental, agricultural, and natural resource ethical issues. Each chapter has been prepared as a separate manuscript for publication. The overall sequence moves from previous research on reporting what helps instructors teach critical thinking to development of a new assessment tool specifically for critical thinking regarding environmental ethics, to a report on one attempt to influence students' critical thinking in a large introductory agriculture and natural resources course.

Chapter 2, 'Critical Thinking for Natural Resource, Agricultural, and Environmental Ethics Education', previously published in the *Journal of Natural Resources & Life Sciences Education*, is a literature review of the factors influencing the development of critical thinking in the classroom and a discussion of applying the findings in an environmental ethics course. Research on critical thinking pedagogy was organized into three categories; (1) student characteristics, abilities, and behaviors, (2) professor characteristics, abilities, and behaviors, and (3) curricula and activities. Teaching critical thinking in regards to environmental ethics can be especially delicate given the competing value systems of students (Casari & Johnson, 1995) and the intense emotions students can feel about environmental issues (Hofreiter, Monroe, & Stein, 2007). A discussion of special considerations for the ethics teacher concludes the article.

Chapter 3 reports on the development and validation of a mixed method assessment tool for critical thinking about environmental ethics. Numerous assessments for critical thinking exist. Some assessments focus on general critical thinking ability while others are targeted within a discipline such as nursing or business. A quantitative tool, the Environmental Ethics Critical Thinking Assessment, was developed and validated with Item Response Theory. A qualitative tool was also developed and tested to give a more nuanced and complete picture of students' critical thinking abilities.

Chapter 4 uses a mixed methods approach to examine freshmen students' critical thinking about environmental ethics upon entry to an introductory course on agriculture and natural resources. The qualitative and quantitative assessments developed in Chapter 2 were administered to 592 students. Step-wise regression showed that gender and critical thinking disposition were significant predictors of critical thinking skills. Critical

thinking dispositions were also measured with the UF-EMI and analyzed. Gender, strength of environmental views, and expected grade were significant predictors of Cognitive Maturity. Expected grade, strength of environmental views, and strength of political views were significant predictors of Engagement. Gender, expected grade, strength of environmental views, and strength of political views were significant predictors of political views. Evidence from this study suggests students can perform well on a multiple-choice assessment, but when given a short writing task where they must generate their own responses, most use few critical thinking skills.

Chapter 5 expands upon the work in chapter 4 and is a mixed methods analysis of the change in all students' critical thinking in an introductory course on agriculture and natural resources pre-post semester. Overall, 46% of students improved their score on the Environmental Ethics Critical Thinking Assessment from pre- to post-semester. Students' critical thinking disposition, gender, time spent on the assessment, number of previous agricultural courses, and expected grade were significant predictors of their score on the pre-semester assessment. Disposition, expected grade, gender, time spent on the assessment, and number of previous agricultural courses were significant predictors of students' score on the post assessment. Students' expected grade and their score on the posttest were significant predictors of the change in their assessment score from pre- to post-semester. Qualitative analysis indicates that students improved their use of summarizing an author's ideas in their own words, providing an example to help explain, comparing and contrasting diverging ideas, analyzing the structure of an argument, deriving plausible conclusions, discussing possible consequences, giving reasons to accept a claim, reflecting upon their own thinking, and identifying personal biases.

However, all improvements were minimal and a large majority of students did not improve their use of critical thinking skills on a written assignment from pre to post-semester.

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CHAPTER II

Critical Thinking for Natural Resource, Agricultural, and Environmental Ethics Education

Courtney Quinn, Mark Burbach, Gina Matkin, Kevin Flores

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Abstract

Future decision makers in natural resource fields will be required to make judgments on issues that lack clear solutions and with information complicated by ethical challenges. Therefore, natural resource, environmental, and agricultural professionals must possess the ability to think critically about the consequences of policy, economic systems, and individual human behaviors on the environment. To ensure that future professionals can examine competing claims, university students must develop critical thinking skills that allow them to examine ethical issues surrounding the environment. We review literature on critical thinking specifically in regards to necessary components to creating critical thinking opportunities in the classroom. We then discuss special considerations for teaching critical thinking in the context of natural resource and agriculture ethics education.

Introduction

Today's students are future decision makers who must tackle natural resource issues stemming from human activities. Due to the immediacy of many environmental threats to human and natural communities, proper training of students is essential. It is increasingly recognized that natural resource and agricultural issues have a human dimension. A properly trained student will graduate with professional capacities reaching beyond technical expertise (Jordan et al., 2008). It is evident that training focused on the physical sciences alone is insufficient for solving complex and pressing environmental problems. Social sciences will play a crucial role in helping stop and reverse human caused environmental damage (Mascia et al., 2003). Science educators are aware that students must develop an understanding of the social implications of science including ethical and political affairs (Zeidler et al., 2002). Therefore, a key component of students' education must be the development of critical thinking skills in regards to ethical issues.

Recent discussion has focused on the notion that a key learning outcome of higher education is students' ability to think critically about and across subjects studied (Kronholm, 1996; Tsui, 2002) and transfer those abilities to job requirements (Pithers, 2000). Despite the need for critical thinking, researchers have often found low levels of critical thinking in students, regardless of assessment methods (Keeley et al., 1982; Zascavage et al., 2007). Though critical thinking is often a stated educational goal, encouragement and development of critical thinking in university classrooms is rare (Norris, 1985; Browne and Freeman, 2000). Overall, the conclusion is that the university system does not consistently produce critical thinkers (Paul, 1993; 2005, Burbach et al.,

2004). Mahaffy (2006) laments the struggle of instructors who encourage students to engage in critical exploratory research beyond a cursory Google search. However, classroom instructors can also be an impediment to critical thinking. Classroom instruction is often didactic and one-dimensional, lacking exciting twists and conflict where students can question their own thinking and the thinking of others (Paul, 1993).

More specifically, students of higher education whose focus is on environmental issues lack a critical view of science that precludes them from thinking critically about the formulation and practical implications of scientific claims (Jones and Merritt, 1999a). Rudd et al. (2000) found deficits in the critical thinking of agricultural students. Zimdahl (2000) concluded that the lack of critical thinking in environmental and agricultural university programs extends to faculty who judge agriculture's progress by technological success but disregard ethical questions raised by that success.

The omission of critical thinking in regards to ethical implications of both natural resources and agricultural issues is dangerous because professionals in these fields make decisions that have profound economic, social, and ecological consequences (Jones and Merritt, 1999b). To counter concerns about inflexible and uncritical thinking by students in academia, researchers have been calling for critical thinking to be a skill of any graduating university student (Paul, 1989; van Gelder, 2005). However, proclaiming the need for critical thinking is easier than ensuring its presence in the classroom.

This paper first examines educational components that research has shown promote critical thinking in undergraduate classrooms. Second, we examine specific considerations for teaching critical thinking concerning environmental, natural resource, and agricultural ethical issues.

What is Critical Thinking?

Paul (1993) suggests that “critical thinking is the art of thinking about thinking while you’re thinking so to make your thinking more clear, precise, accurate, relevant, consistent, and fair” (p. 136). Rudd et al. (2000) define critical thinking 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.” One reason a single definition of critical thinking remains elusive is that critical thinking is related conceptually to reflective judgment, problem framing, higher order thinking, logical thinking, decision-making, problem solving, and the scientific method (Giancarlo and Facione, 2001).

One of the most prominent definitions of critical thinking comes from the Delphi project. Facione (1990) headed a consortium of experts representing a variety of academic disciplines who reached consensus on a definition of critical thinking. Their definition states “We understand critical thinking to be purposeful, self-regulatory judgment that results in interpretation, analysis, evaluation, and inference, as well as explanation of the evidential, conceptual, methodological, criteriological, or contextual considerations upon which that judgment is based (p. 2)”. The Delphi model includes six critical thinking skills and seven dispositions. The six core critical thinking skills are analysis, inference, interpretation, explanation, self-regulation, and evaluation. The seven critical thinking dispositions are inquisitive, systematic, judicious, truth-seeking, analytical, open-minded, and confident in reasoning.

The literature on the definition of critical thinking is vast and this paper is not intended to be a review of all critical thinking conceptualizations. For the purpose of

this paper, the authors subscribe to a definition of critical thinking that combines the conceptualization of critical thinking as a confluence of skills and dispositions (Facione, 2006) with the view that critical thinking is a process (Huitt, 1998). Critical thinking for agricultural and natural resource ethics is the process of examination and critique to make informed judgments regarding the use of natural resources and the resulting environmental, social, and economic consequences.

Education for Critical Thinking Development

The Delphi group recognizes the importance of critical thinking in education. “Critical thinking is essential as a tool of inquiry. As such, critical thinking is a liberating force in education and a powerful resource in one's personal and civic life (Facione, 1990, p.2)”. However, critical thinking must be taught (Beyer, 1987). Research has shown that college students can experience significant gains in critical thinking (Burbach et al., 2004; Gadzella and Masten, 1998; Logan, 1976). For the last century, researchers, educators, and others have emphasized the importance of critical thinking as one of the highest priorities in a college education (Osborne, 1934; Dressel and Mayhew, 1954; Ennis, 1987; Gadzella and Masten, 1998; Halonen and Gray, 2001). Furthermore, studies to identify needs of future agriculture and natural resources-related education in a global economy found that employers recognize an increasing need for education curricula to include development of critical thinking skills (National Research Council, 2009; Scanlon et al., 1996).

The college experience can foster the development of critical thinking in students. However, current college graduates often lack critical thinking skills. This disconnect poses the need to examine elements that are shown to increase critical thinking in college

students. The following section is a literature review of the instruction of critical thinking in undergraduate classrooms.

Components of Critical Thinking in Education

Research has offered guidance on the components that contribute to critical thinking in students. However, much of the literature on necessary components of critical thinking development is haphazard, with no recent meta-analysis on key components for development of student critical thinking in the classroom. Additionally, many academic papers use the term ‘critical thinking’ somewhere in the paper, often as a stated need or outcome. However, critical thinking is not specifically addressed as the goal of the research or case study and not in the title, abstract, or keywords. Therefore, this paper does not make claim to a meta-analysis of all recent literature that addresses critical thinking in the classroom. However, many papers do address critical thinking explicitly. During our literature review it became evident that critical thinking research can be categorized into three classroom elements. To address the need to simplify the vast offerings of critical thinking pedagogy literature we organize necessary elements into three categories; (1) student characteristics, abilities, and behaviors, (2) instructor characteristics, abilities, and behaviors, and (3) curricula and activities.

Student Abilities, Behaviors, and Characteristics

Students enter each classroom with a set of abilities, behaviors, and characteristics (ABCs) that influence their ability to think critically. Instructors must be aware of the traits students bring to the classroom. Student ABCs that are significant to critical thinking include critical thinking disposition, a tendency towards confirmatory bias, and cognitive developmental level.

Facione et al. (1995) note that an individual's disposition to think critically is as important as an individual's critical thinking skills. Critical thinking disposition is a person's inclination to use critical thinking when problem solving, evaluating ideas, or making decisions (Giancarlo and Facione, 2001). Students with low critical thinking disposition may lack the drive to engage in classroom activities that challenge a student's thinking, values, or beliefs or to participate with other students in critical thinking activities. Students enter a classroom with a defined critical thinking disposition. However, Rudd et al. (2004) demonstrate that college instructors can positively influence student critical thinking disposition.

Related to critical thinking disposition is students' tendency to seek information that confirms already held views (Nickerson et al., 1985; Mynatt et al., 1977) in the absence of conflicting perspectives and active discussion (Browne and Freeman, 2000). van Gelder (2005) notes that the mind has intrinsic tendencies toward illusion, distortion, and error. Research indicates that people have a cognitive bias that leads them to misconstrue new information to support their previously held hypotheses (Rabin and Schrag, 1999). When confronted with data contrary to currently held opinions regarding socioscientific issues, many students ignore or reject new information (Zeidler et al., 2002). In a qualitative study with university instructors, Halx and Reybold (2005) found that many instructors equate students' religious beliefs with their critical thinking disposition. The human desire to hold firmly to our beliefs, values, and attitudes can provide a sizable obstacle to utilizing critical thinking in the classroom. Instructors must address the tendency for confirmatory bias. One way to do this is through active learning and cognitive dissonance, both discussed in the review on curricula and activities.

Students' developmental level can influence their ability to think critically. Instructors must be aware of students' development level to structure activities accordingly (Barbuto, 2000). Students who are not capable of objectively reflecting on their thoughts and feelings will find it difficult to engage in non-egocentric critical thinking. However, a crucial difficulty is assessing students' cognitive developmental level. Kegan's (1982) construct is helpful in considering developmental level, but the process of assessing a student is time prohibitive. Nonetheless, several researchers have recommended ways instructors can assess and explicitly address their students' intellectual development so they can design more appropriate coursework (Cunningham, 1996; Rodgers, 1992; Wolcott, 2000; Wolcott and Lynch, 1997). Instructors must seek to teach to the developmental level of their students despite difficulties in determining their level.

Instructor Abilities, Behaviors, and Characteristics

Instructors are a crucial element for fostering critical thinking in the classroom (McMillan, 1987; Aretz et al., 1997). As with students, instructors bring their own ABCs to a classroom. Research has indicated that instructors impact critical thinking in the classroom through their pedagogical philosophy, assumptions regarding students, personal definition and understanding of the concept of critical thinking, willingness to engage in creativity and experimentation in teaching methods, ability to model a strong critical thinking disposition and process, and ability to create a classroom environment conducive to critical thinking.

Just as researchers have a variety of definitions of critical thinking, so do faculty. The primary source of instructor perceptions about critical thinking is their own

undergraduate experiences (Halx and Reybold, 2005). This leads to mixed definitions and pedagogical experimentation in teaching critical thinking in the classroom. Most instructors lack a complete understanding of critical thinking and therefore will have difficulty teaching it to students (Paul, 2005; Hass, 1998). This confusion may help to explain why evidence suggests that many faculty have not embraced critical thinking as an essential value (Hass et al., 1998).

An instructor's pedagogical philosophy and approach to critical thinking development has an effect on student learning (Balin et al., 1999; Halx and Reybold, 2005; Tsui, 2001). For example, Tsui (2001) found that an instructor's belief that students can develop critical thinking skills is a prerequisite for student cognitive growth in the classroom. Case studies indicate that at schools with more selective admissions, instructors feel more comfortable helping students develop higher-order thinking skills (Tsui, 2001). In contrast, instructors who are frustrated with students' low motivation and poor academic preparation are less likely to engage classrooms in activities that foster critical thinking. This finding has important implications for a student's opportunity to develop critical thinking. If faculty perceive students to be uninterested in developing critical thinking skills, whether or not this assumption is correct, instructors may ignore activities that foster critical thinking. Therefore, faculty members must identify and counteract their own biases to assure that all students have classroom opportunities to develop and maintain critical thinking ability (Halx and Reybold, 2005).

Developing critical thinking skills in students is a challenge that requires creativity and experimentation (Tsui, 2001; Dlugos, 2003). However, instructors often use the type of teaching they experienced; lectures without any active learning

opportunities for students to develop critical thinking (Browne and Meuti, 1999).

Different and varied pedagogy can be difficult and time consuming to create, but the outcome will be students with increased critical thinking ability.

Instructors must model both a strong critical thinking disposition as well as the process of thinking through an idea or problem (McKendree et al., 2002; Hofreiter et al., 2007). The role of the teacher is to create an emotional climate consistent with a search for stronger beliefs (Browne and Freeman, 2000). When students observe a lecturer's excitement and open searching for answers, they are more likely to tolerate the discomfort associated with their own loss of certainty regarding their assumptions, knowledge, and values (Browne and Freeman, 2000). An instructor may model solving a problem by talking through their own reasoning of a problem and drawing representations that illustrate their thought process (McKendree et al., 2002). Friere (1993) stated that instructors must demonstrate a willingness to change their own opinions. This openness to change will demonstrate the disposition towards intellectual inquiry that students need to engage in critical thinking.

University instructors must provide a classroom environment conducive to critical thinking. Instructors may need to create a strong positive bond with their students and provide a safe, supportive environment so students can engage in critical thinking (Keeley and Shemberg, 1995). When this is accomplished, students will be comfortable expressing their opinions in an environment that is free from threat and intimidation (Jungst et al., 2003). It is particularly important that instructors build positive relationships with students since students are capable of sensing their instructor's attitude toward them (Wilson, 2008).

Curricula and Activities

Most research on critical thinking instruction has focused on specific classroom activities that promote critical thinking. Overtly teaching critical thinking skills within the context of a course can improve students' critical thinking (Friedel et al., 2006; Hofreiter et al., 2007). Instructors must immediately let students know that gaining and practicing critical thinking skills will be a part of the class experience. Course descriptions must communicate how critical thinking will be integrated in a course and course objectives must reflect teaching for critical thinking (Rudd, 2009).

Writing assignments affect student critical thinking (Tsui, 2002; Chen and Lin, 2003; Powell, 2009). Possible written assignments that include critical thinking are: (1) assessing the written work of peers, (2) rewriting one's own work, and (3) writing assignments asking students to reflect critically upon their performance and growth (Tsui, 2002). Having a paper critiqued by an instructor and taking essay exams is positively related to student self-reported growth in critical thinking (Tsui, 1999). Tsui's research also showed a negative relationship between critical thinking development and taking multiple-choice exams. Instructors are increasingly using forms of assessment other than a multiple-choice exam to evaluate students' development of critical thinking (Powell, 2009).

The writing assignment most often linked to critical thinking development is journaling. As a process of self-reflection, journaling may increase critical thinking (Jones and Brown, 1993; Lizzio and Wilson, 2007). Opportunities for self-reflection deepen student learning (Thompson, 1998, Grossman, 2009). Journal writing enhances critical thinking as measured by student perceptions, instructor perceptions, and course

exams (Seshachari, 1994; Connor-Greene, 2000; Mayo, 2003a; Mayo, 2003b) and provides students with the opportunity for active and regular self-reflection (de Acosta, 1995). Instructors must pay attention to the quality and depth of student reflection and provide constructive feedback. To increase the quality and depth of journal responses, instructors must support students in examining their assumptions, considering evidence from multiple perspectives, and taking responsibility for making a considered conclusion based on their reflections (King and Kitchener, 2004).

Collaborative learning has shown a positive relationship with students self-reported (Tsui, 2000) and empirically tested (Gokhale, 1995) critical thinking skills. Students who participate in collaborative learning perform significantly better on tests of critical thinking than students who studied individually. Small group work and discussion is posited to be superior to the traditional lecture at fostering critical thinking (Ishiyama et al., 1999).

Active learning is a key ingredient in classrooms that promote critical thinking.

Active learning has been defined as,

The process of having students engage in some activity that forces them to reflect upon ideas and how they are using those ideas. Requiring students to regularly assess their own degree of understanding and skill at handling concepts or problems in a particular discipline. The attainment of knowledge by participating or contributing. The process of keeping students mentally, and often physically, active in their learning through activities that involve them in gathering information, thinking, and problem solving (Collins and O'Brien, 2003).

Burbach et al. (2004) found that active learning techniques increased critical thinking. Active learning activities can include: (1) instructor-mediated reaction journals, (2) service-learning projects (Sedlak et al. 2003), (3) small group projects involving contextual scenarios, (4) case studies, (5) role-plays, and (6) student presentations. Active

learning can occur through class discussion (Tsui, 2002). Case studies coupled with group discussions promote critical thinking (Mayo, 2002). Students should be encouraged to be curious, raise objections, ask questions, and point out difficulties in the instructor's position (Facione, 1990). Browne and Freeman (2000) identify key questions that can be used by an instructor during discussion to move a class toward critical thinking such as: 'What words or phrases are being used in an ambiguous fashion?' and 'What evidence was provided for the claims in the reasoning?'

One way to incorporate active learning into a classroom is to use structured controversy (Herreid, 1996; Payne and Gainey, 2003). Halx and Reybold (2005) found that many instructors used structured controversy, or created cognitive dissonance in students, to improve critical thinking. Controversy increases the likelihood that students will desire to evaluate claims (Browne and Freeman, 2000). The basis of academic controversy is a statement or an issue that can be supported or opposed (Jungst et al., 2003). Case studies specific to the discipline and course can be used to create and explore controversy in the classroom (Hofreiter et al., 2007). Students can identify stakeholders, examine and analyze arguments, and make their conclusions known to other students through debate or presentations with classmates.

Special Considerations for Natural Resources and Agriculture

The above components that promote critical thinking in undergraduate classrooms offer guidance to natural resource courses when addressing ethical considerations. However, there are some special considerations for instructors when teaching the complex and emotionally charged aspects of natural resource and agricultural ethics.

Context matters when developing critical thinking (Norris, 1985; Ennis, 1989). Despite the broad educational goal of developing critical thinking skills for all college graduates, the authors contend that critical thinking skills for natural resources, environmental, and agriculture professionals are essential. Issues within and across the respective fields are complex and have no clear solutions. Natural resource use encompasses social, ecological, and economic considerations. Therefore, natural resource, environmental, and agriculture education for the 21st century must include the social sciences and strive to develop critical thinking skills and enable problem solving (Palmer, 1998).

Ciulla (1996) argues that students must be taught about logical fallacies and gain experience evaluating others' and their own moral values. Moral debate is often merely statements of preference for one conclusion or another, lacking any evaluation of the arguments used to reach a conclusion. She concludes that if students cannot provide well-informed arguments then they need to reexamine their beliefs. Additionally, students training to work in different natural resources fields may have competing value systems (Casari and Johnson, 1995). For example, students in conservation and water science may have different views of water use than students of crop science (Casari and Johnson, 1995). Students must understand their own values, the paradigm and assumptions made by their chosen profession, and the values other stakeholders place on natural resources. This makes natural resource and agricultural ethics education and critical thinking about environmental, natural resource, and agricultural issues essential for all students.

Critical thinking skills are also essential for students who graduate from natural resource management programs because they will have to deal with controversial public issues throughout their professional careers (Jungst et al., 2003). Environmental problems must be examined in a holistic interdisciplinary manner that incorporates social, cultural, physical, and ecological analysis (UNESCO: Intergovernmental Conference on Environmental Education, 1977). However, fostering critical thinking in natural resource education may be more difficult than in other disciplines, yet more important (Jones and Merritt, 1999). The complexity and emotional aspects of many environmental ethics issues will require special attention on part of instructors.

Debates regarding natural resource ethics are often full of conflict, emotion, and have ambiguous answers. Hofreiter et al. (2007) found that students' emotions about environmental issues hindered their ability to apply critical thinking processes. They concluded that significant time must be dedicated to discussing students' emotions on issues and the role emotions play in critical thinking. Additionally, the strong emotions elicited by ethics debates will require instructors to ensure a safe classroom atmosphere so students can express and challenge their beliefs without fear of embarrassment or chastisement.

As mentioned earlier, Jungst et al. (2003) specifically support the use of structured controversy when teaching natural resource ethical issues. The movement towards using real-life case studies aids students in analyzing problems that reflect the complexity of the real world, making learning more meaningful (Tan et al., 2001). The process of analyzing an issue and engaging in argumentation engages students in critical thinking while they go through the problem solving process (Zeidler et al., 1992). Jordan

et al. (2008) found that participation in creating and analyzing future scenarios helped students develop a broader capacity to think and act systemically regarding agriculture and natural resource issues. Future scenarios were a tool used by current professionals in the 2005 Millennium Ecosystem Assessment (MSE, 2005).

Reflection is most applicable in courses where students experience strong cognitive dissonance and must examine their assumptions and perspectives (Keily, 2005). Courses that require students to examine their own values and beliefs will need to allow plenty of opportunity for structured reflection. Reflection may also be an appropriate assessment tool for student active learning and participation.

Conclusion

This paper reviews literature from relevant research regarding critical thinking development in the classroom. By categorizing critical elements into three categories; 1) student abilities, behaviors and characteristics, 2) instructor abilities, behaviors and characteristics, and 3) curricula and activities, we hope to make the process of implementing critical thinking elements into a classroom less daunting for instructors.

Critical thinking development for natural resource and agriculture students offers many opportunities for future research. First, we propose that the classroom activities previously tested as a group be tested individually, to understand which elements truly impact critical thinking. For example, in a course that uses numerous writing assignments, are there assignments that specifically increase critical thinking? Are individual students impacted by different assignments? Last, researchers need to test the relationship between additional student variables and critical thinking. For example, is

there a relationship between student's religious beliefs and their critical thinking disposition?

Critical thinking skills are essential for natural resource professionals who must make decisions with ethical, political, and economic implications. Decisions regarding human use of natural resources will have ecological implications for decades, even centuries. Currently, students are graduating without a high disposition towards critical thinking or the skills necessary to engage in complex problem solving and analysis. Given the complexity, immediacy, and long-term considerations of many environmental concerns, the education system must actively develop critical thinking skills in future natural resource, environmental, and agricultural professionals. Research has offered guidance on elements for the development of critical thinking in the classroom including the characteristics of students and instructors as well as pedagogy. The task for instructors is to be aware of how a multitude of elements affects critical thinking in the classroom and to implement activities that foster critical thinking in students.

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CHAPTER III

A Mixed Methods Study of First-year Students' Critical Thinking Disposition and Skills

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Abstract

This mixed-methods study examined college freshmen students' critical thinking dispositions and critical thinking skills regarding agricultural and natural resource issues. First-year students in a large introductory course completed a multiple-choice critical thinking assessment, the University of Florida–Engagement, Maturity, and Innovativeness assessment (UF-EMI), and a short writing assignment regarding a local conservation issue. Step-wise regression showed that gender and critical thinking disposition were positively related to critical thinking skills. Gender and strength of environmental views were positively related to cognitive maturity. Strength of political views and strength of environmental views were positively related to engagement. Gender, strength of political views, and strength of environmental views were positively related to innovativeness. Expected grade was negatively related to all three areas of critical thinking disposition. Qualitative analysis of six critical thinking skills demonstrates students' sparse use of critical thinking skills in responding to a letter-to-the-editor. This study demonstrates that freshmen students enter college with some critical thinking skills but low ability to implement said skills.

Introduction

The need to develop critical thinking skills in undergraduate agricultural and natural resources students has never been greater. Employers increasingly expect recent graduates to have the ability and desire to think critically (AACU, 2009; Arum & Roska, 2011; Casner-Lotto, Barrington, & Wright, 2006). The 2000 National Education Goals Panel (1991) called for an increase in the percentage of college graduates with the ability to think critically. In addition, given the tremendous problems agricultural and natural resource professionals will face in the coming decades, students need to learn critical thinking skills while in college. Albert Einstein famously quoted, “We cannot solve our problems with the same thinking we used when we created them.” In response, colleges and universities are encouraging the development of critical thinking in the classroom.

Assorted definitions of critical thinking abound. Critical thinking is often conceptualized as specific skills (Browne & Keeley 1998; Facione, 1990) or as a process or practice (Balin, Case, Coombs, & Daniels, 1999). Rudd et al. (2000) define critical thinking 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.”

In this study, we utilize the critical thinking definition developed by Facione (1990). Six critical thinking skills, and many sub-skills and examples, were developed through a Delphi study where forty-six top researchers in the field worked for over a year to create a consensus critical thinking definition. The Delphi definition states, “We understand critical thinking to be purposeful, self-regulatory judgment that results in interpretation, analysis, evaluation, and inference, as well as explanation of the evidential,

conceptual, methodological, criteriological, or contextual considerations upon which that judgment is based” (Facione, 1990).

The Delphi study was also one of the first to propose that a persons’ disposition towards using critical thinking is equally important to critical thinking skills. Facione (2000) identified disposition as an individual’s “habitual ways of acting” (p. 4). Irani et al. (2007) stated that critical thinking disposition is the “gateway” through which one engages in critical thinking. Recently, Lamm et al. (2011) reported moderate correlations between critical thinking disposition and problem solving style and learning style in undergraduate and graduate students.

Discouragingly, mounting evidence indicates the call to increase student critical thinking has not been met (Browne & Freeman, 2000; Del Bueno, 2005; Keeley, Browne, & Kreutzer, 1982; Norris, 1985; Zascavage, Masten, & Schroeder-Steward, 2007). Students are frequently entering the workforce lacking critical thinking skills (AACU 2009; Partnership for 21st Century Skills, 2006). Overall, the conclusion is that the university system does not consistently produce critical thinkers (Paul, 1993; 2005, Burbach, Matkin, & Fritz, 2004). The challenge before us, as educators, is to evaluate why students are leaving our institutions without a skill so vital to our economic and environmental sustainability and what we can do to change the situation. However, before we can create a plan to increase students’ critical thinking skills, we first need to gauge incoming students’ skills and dispositions. We need to assess agricultural and natural resource students upon entry to college. To know where we must go, we must first know where our students are.

Purpose and Objectives

The overall aim of this study was to assess freshmen students' critical thinking skills and disposition, with the objective of documenting their performances before receiving any college-level instruction. We used both quantitative and qualitative data to assess first-year college students' critical thinking disposition and skills. Both assessment methods focused specifically on critical thinking in an agricultural and natural resources context.

Quantitative Research Questions

1. Can freshman students' think critically about agriculture and natural resource issues?
2. What are freshmen students' disposition to use critical thinking?
3. What is the relationship between the student demographics and critical thinking disposition and skills?

Qualitative Research Question

1. How do students use critical thinking skills in a written assignment regarding an environmental ethical issue?

Methods

To generate a more in-depth and accurate picture of freshmen students' critical thinking skills, this study used a concurrent triangulation mixed-methods approach (Figure 1) (Creswell, 2009). Quantitative and qualitative data were gathered simultaneously during the first week of a semester, and both databases compared to confirm or disconfirm findings and construct a more complete understanding of college freshmen and their critical thinking abilities.

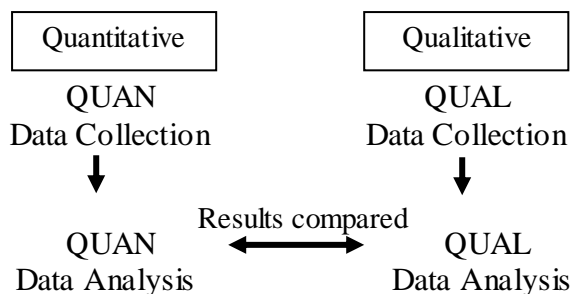


Figure 1. Concurrent triangulation mixed methods design (from Creswell, 2009).

Participants

This study was conducted in the Fall 2010, Spring 2010, and Fall 2011 semesters at a large land grant university in the Midwest. Cohorts were selected via their enrollment in a required introductory course for all students within the College of Agricultural Sciences and Natural Resources at the university. The class consisted of a twice or thrice weekly lecture and once a week discussion section with one of 16 instructors. Over three semesters, 809 students completed the course, 592 of whom were freshmen and included in the study.

Procedure and Measures

Within the first week of each semester, students completed an online critical thinking skills assessment outside of class time. The 12-item multiple-choice assessment, requiring students to think critically about agriculture and natural resource issues, was developed for this study. Item-Response Theory (IRT) was used to validate the instrument. IRT is a model-based measurement in which latent trait estimates depend on both responses and the properties of the items. IRT is a nonlinear response model that simultaneously accounts for differences between persons and differences between items (De Ayala, 2009).

Critical thinking disposition was measured with the University of Florida–Engagement, Maturity, and Innovativeness assessment (UF-EMI) (Irani et al., 2007). The instrument is a 26-item, five-point Likert-scale. The UF-EMI has three critical thinking disposition constructs; Engagement, Cognitive Maturity, and Innovativeness. A high score in Engagement signifies the ability to anticipate situations where good reasoning is necessary. Cognitive Maturity is the awareness of one’s own predispositions and biases. Innovativeness is indicated by intellectual curiosity of challenges and active searching to know more. Mean score and step-wise regression analysis on each critical thinking disposition and overall critical thinking skill was performed with SPSS.

Next, students participated in a lecture introducing the concept of critical thinking and completed an in-class writing assignment. Students in the fall of 2011 ($N=347$) were asked to evaluate and respond to a letter-to-the-editor of a local newspaper on a local environmental issue; the preservation of the Salt Creek Tiger Beetle. Students had twenty minutes to read and respond to the letter as if they were writing a response back to the paper. Students entered their answers in QualtricsTM. Data was then transferred to, and analyzed with MaxQDA. A qualitative codebook (Figure 2) was created following the six critical thinking skills and sub-skills developed by Facione (1990). Each sub-skill served as a theme. Each student’s entry was read with the purpose of coding any use of the 17 sub-skills.

Table 1. Qualitative codebook for critical thinking skills developed from Facione (1990)

Skill	Sub-skills
Interpretation	summarizes the author's words in own words uses an example to explain
Analysis	defines terms compares and contrasts divergent viewpoints analyzes the overall structure of the argument
Evaluation	assesses the credibility of supporting information or evidence assesses the credibility of views or opinions assesses if any additional information might strengthen or weaken the argument
Inference	derives plausible conclusions formulates alternatives for solving a problem discusses possible consequences from different choices
Explanation	gives reasons for accepting a claim anticipates and responds to possible criticism or others' opinions logically communicates thinking
Self-regulation	recognizes need for further inquiry reflects upon and justifies own thinking process identifies personal biases

Results

Quantitative Results

Five hundred and ninety-two freshmen completed the online multiple-choice critical thinking skills assessment over three semesters. Ages ranged from 17 to 26, though only 12 students were 20 or older. Fifty-seven percent of the sample was male and 43% was female. Students came from 19 different states and two countries outside of the United States. However, 87% of students consider themselves residents of the state in which the study was conducted. At the beginning of the semester, 77% of students expected to earn an A in the course and 21% expected to earn a B. Students had a self-reported average GPA of 3.5 (high school graduation GPA). Fifty-five percent

of students reported having never left the United States while 39% have briefly traveled abroad.

Students reported on the types and number of courses taken in high school pertaining to the instrument. Nineteen percent of freshmen students in the current course had taken a previous ethics course. Fifteen percent of those with a previous ethics course had experience in an environmental ethics course. Forty-four percent of students had previously taken at least one course in logic or critical thinking. Almost half of the students had taken at least one agriculture course while half of those students had taken two or more. The same number of students had previous experience in a course on natural resources.

Students were asked about the strength of their political, religious, and environmental views. Specifics on their opinions (ie. conservative or liberal) were not asked. Only 11% of students reported 'very strong' political views while 30% reported 'not strong' views. Interestingly, 33% of students have a 'very strong' religious view and 21% of students report 'very strong' environmental views.

Students self-rated their leadership in three areas; in class, in extra-curricular activities, and in their social group. While only 26% of students rated themselves as a leader in-class, 41% claimed leadership in extra-curricular activities and 60% did so in their social group.

Disposition

The UF-EMI inventory was used to measure students' critical thinking disposition. The total score on the instrument ranges from 26 to 130, a higher score indicating a high critical thinking disposition. Students' total scores ranged from 65 to

128. Engagement scores can range from 11 to 55. Students' Engagement scores ranged from 26 to 55. Cognitive Maturity scores can range from 8 to 40. Students' ranged from 18 to 39. Innovativeness can range from 7 to 35. Students' ranged from 17 to 35.

Critical Thinking Skills

Mean score was 72% with a range from zero correct to 100% (Figure 3). Over half of the students scored above the 75 percentile on the assessment. However, 22% of students scored a 50% or below.

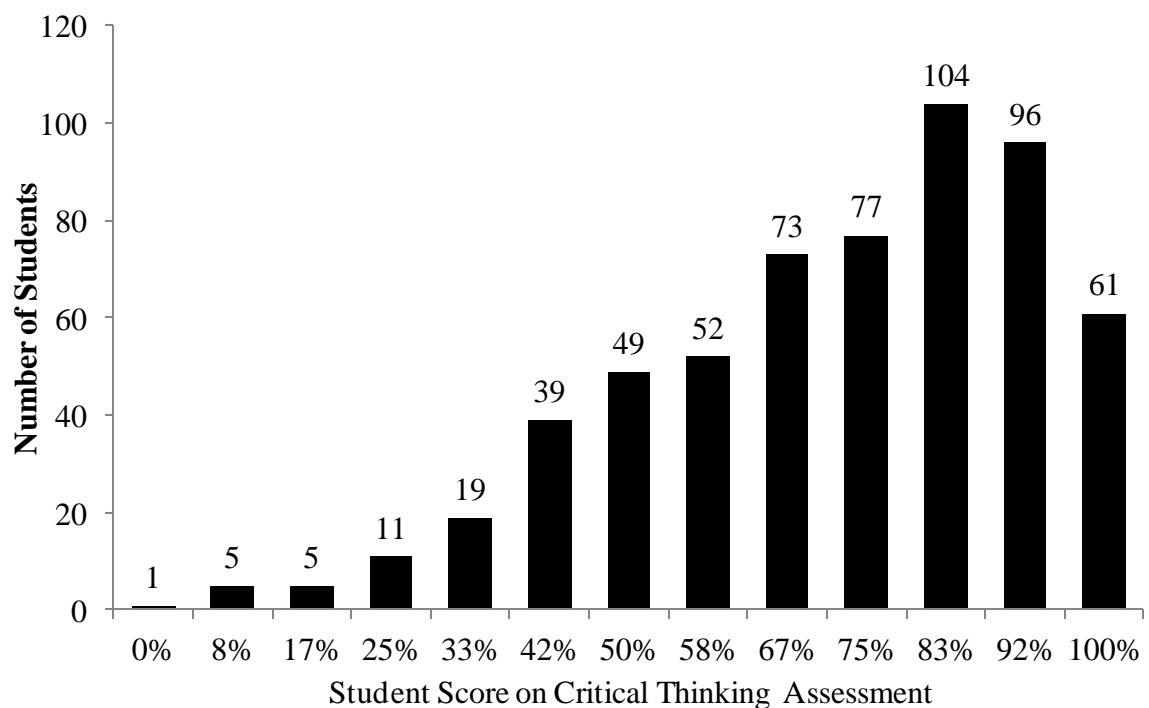


Figure 2. Freshmen students' critical thinking skills score.

A series of step-wise regressions were estimated on critical thinking skills, Cognitive Maturity, Engagement, and Innovativeness. The step-wise regression for critical thinking skills showed that gender ($\beta = .16, p < .000$) was a significant predictor of

critical thinking skills (Table 1). This means that female students scored higher on the critical thinking assessment. Also, students' critical thinking disposition was positively related to students' critical thinking skills ($\beta = .16$, $p < .000$), indicating students who are inclined to use critical thinking skills do score higher on a measure of critical thinking.

Table 2. Step-wise Regression for Critical Thinking Skill (N=592)

Variable	B	SE B	β
Constant	3.394	1.060	
Gender	.814	.207	.159
Critical Thinking Disposition	.042	.011	.157

$R^2 = 0.057$; $F = 17.504$; $p < .000$

Step-wise regression for critical thinking disposition showed that gender ($\beta = .10$, $p < .000$), strength of environmental views ($\beta = .21$, $p < .000$), and strength of political views ($\beta = .12$, $p < .000$), have a significant positive relationship with critical thinking disposition. Self-rating of in-class leadership ($\beta = -.37$, $p < .000$), has a significant negative relationship with critical thinking disposition.

Table 3. Step-wise Regression for Critical Thinking Disposition (N=592)

Variable	B	SE B	β
Constant	96.043	2.042	
Gender	1.993	.686	.104
In class leadership	-7.093	.711	-.365
Strength of environmental views	3.339	.594	.207
Strength of political views	1.902	.576	.123

$R^2 = 0.261$; $F = 51.623$; $p < .000$

The step-wise regression for cognitive maturity showed that gender ($\beta = .17$, $p < .000$) was a significant predictor of cognitive maturity (Table 2). Also, strength of environmental views was positively related to students' level of cognitive maturity ($\beta =$

.15, $p < .000$), which indicates that freshman students with strong environmental views have higher levels of cognitive maturity. Students' expected grade ($\beta = -.14$, $p < .000$), was negatively related to cognitive maturity. This indicates that students who expected a higher grade in the course actually have lower levels of cognitive maturity.

Table 4. Step-wise Regression for Cognitive Maturity (N=592)

Variable	B	SE B	β
Constant	28.199	.72	
Gender	1.031	.257	.167
Strength of environmental views	.789	.220	.149
Expected grade	-1.029	.301	-.142

$R^2 = 0.071$; $F = 13.74$; $p < .000$

The step-wise regression for engagement showed that expected grade ($\beta = -.20$, $p < .000$) was a significant negative predictor of engagement (Table 3). Also, strength of political views ($\beta = .20$, $p < .000$), and strength of environmental views ($\beta = .23$, $p < .000$), are positively related to engagement. This indicates that freshman with strong political and environmental views have a higher level of engagement.

Table 4. Step-wise Regression for Engagement (N=592)

Variable	B	SE B	β
Constant	37.593	.919	
Expected grade	-1.98	.393	-.191
Strength of environmental views	1.766	.302	.157
Strength of political views	1.518	.291	.204

$R^2 = 0.168$; $F = 39.276$; $p < .000$

The step-wise regression for innovativeness showed that expected grade ($\beta = -.19$, $p < .000$) was a significant negative predictor of innovativeness (Table 4). Also, gender ($\beta = .15$, $p < .000$), was positively related to students' level of innovativeness indicating female freshman tend to have significantly higher levels of innovativeness. Strength of

political views ($\beta = .17$, $p < .000$), and strength of environmental views ($\beta = .23$, $p < .000$), were positively related to innovativeness.

Table 5. Step-wise Regression for Innovativeness (N=592)

<i>Variable</i>	<i>B</i>	<i>SE B</i>	<i>β</i>
Constant	22.624	.748	
Gender	.961	.248	-.147
Expected grade	-1.363	.279	-4.885
Strength of environmental views	1.229	.214	.225
Strength of political views	.869	.207	.166

$R^2 = 0.163$; $F = 28.383$; $p < .000$

Qualitative Results

While it is important to quantitatively measure students' critical thinking skills, we wanted to delve deeper into analyzing students' abilities. While the quantitative results indicate most students have at least basic critical thinking skills, the qualitative results paint a very different picture. Each skill and sub-skill (Figure 1) was reviewed for examples of student use. Below, we report on the use (or lack of use) of each sub-skill and provide overviews and specific examples from students' writing.

Interpretation

No student summarized the original author's intent in his or her own words. However, with a short writing assignment this is not too surprising. Students often used an example to explain a point. "Many animals do become extinct because of Mother Nature, but some things that happen in nature are caused by humans. Some examples are flooding, air pollution, and the spreading of chemicals." Many students compared conservation efforts for the Tiger Beetle to projects for other creatures or ecosystems; using examples such as humans, polar bears, gray wolves, and the rainforest to advocate

for preservation. Two students used the example of saving the Bald Eagle from extinction. One student also used this type of example to advocate against preservation. “Bad things tend to happen when we focus entirely on animals. Look at the Missouri River and how they kept water back for a certain bird to nest on sandbars. It resulted in thousands of dollars in flooding damage.” Students often cited important discoveries from animals or plants in nature to persuade for preservation of the Tiger Beetle. “...and I believe the little tiger beetle might possibly have a hidden key to some of those important global problems. Look at the now common item penicillin, without research and testing this would not exist!” Some students also used examples to explain the Tiger Beetle’s importance to the larger ecosystem. “They help keep the number of bugs down to a minimum, much like a cat does with mice- without the cats, the mice population would grow out of control.” The original Letter-To-The-Editor included the idea that researchers of the Tiger Beetle move all remaining beetles to their backyard. One student used humor as an example to dismiss this idea. “Asking researchers to put the beetles in their own backyards is like asking elected officials to uproot citizens and bring them to live in their garages.”

Analysis

Very few students utilized the skill of Analysis. One student defined the correct scientific order of the Tiger Beetle. “First of all the Salt Creek tiger beetle is not a bug as another reader commented. As its name states, it belongs to the beetle order (coleoptera) of insects and not the true bug order (hemiptera).” However, no student analyzed the overall structure of the original author’s argument; though many did criticize specific information or remarks. Given the limited amount of information given to the students

regarding the Salt Creek Tiger Beetle, few students compared and contrasted viewpoints. Most students formulated an opinion and did not question or consider another point of view. The students who did so were a minority. “With that being said, I can see reasons why the individual may oppose expansion.”

Evaluation

A number of students identified that more information would be beneficial, contributing to either an argument for or against, preserving the Salt Creek Tiger Beetle. Most students calling for additional information wanted to see further research to identify the beetle’s role within its environment. One student noted, “The information currently available does not describe the exact role of the Tiger Beetle or the effects of the extinction of the species.” Many students felt that if the Tiger Beetle plays an important role in the ecosystem, such as serving as a top-predator to keep down arthropod numbers that can harm crops, then it would be worth saving. If the Tiger Beetle is essential to the ecosystem or helps humans, that information would weaken the original author’s argument that the Tiger Beetle is worthless. Few students questioned the figures mentioned in the original document, but one student asked, “I wonder how much money this project would really take?”

Many students assessed the credibility of the author’s supporting information and/or opinions. The statement most students questioned regarded the original author’s comment that Mother Nature killed off the dinosaurs and Mother Nature has also determined that the Salt Creek Tiger Beetle go extinct. Numerous students remarked that the beetle is not going extinct due to ‘Mother Nature’ but because of human behaviors. “Nature is not deciding to terminate this species, we are.”

One student questioned the author's statement that the beetle does nothing for the environment. "How does the writer know that the ecology system has made it fine without them? They aren't extinct yet! Therefore, they could still be helping and if they were to go extinct the system might suffer." A few students also questioned the author's supporting information that the land will be taken away from farmers. "...they are found along mud banks of streams and seeps. No farmer will want to plant crops in mud."

Another main point of the original piece questioned by students is the contention that researchers could not possibly get an accurate count of the Tiger Beetle and therefore do not know that there are only 205 in existence. "Being able to count 205 beetles in completely irrelevant to the task that the researchers are trying to accomplish." However, it is important to note that only a few students, out of hundreds made this connection. One student noted, "There are professionals delegated to the task of counting the beetles. It is not some who has no experience; it is someone who completes efforts such as this for an occupation. The count is more than likely accurate." Many students agreed with the original author in questioning the researchers' count and used that assumption to justify not preserving the species.

A few students questioned the opinion that researchers should "round-up" the beetles and keep them in their backyards. "The comment about rounding the beetles up and putting them in their own backyards shows the writer's ignorance. ... completely ignored the fact that Tiger Beetles are wild animals with a specific habitat."

Inference

Few students wrote their responses in a logical format including premises with support and ending with a conclusion. However, a few students did carefully consider

their approach to justifying or refuting protection for the beetle. “If humans did not pollute so much and destroy its habitat, so much money would not be needed to assist the beetle. Due to all that humans have done, the beetle needs help.”

By far, the most often used critical thinking skill was to formulate alternatives for solving the problem. Over fifty students offered an alternative. Most proposed moving the beetle to a zoo or other area and building a suitable replica habitat. Others proposed changes in farming practices that are contributing to beetle decline. Regulating pollution and fertilizers in the area surrounding beetle habitat was one solution. Others suggested finding a pesticide that does not harm the beetle. One student even suggested vertical-farming to reduce the land pressure around beetle habitat. Some suggested relocating the beetles to another area. A number of students suggested making the salt creek area into a national wildlife refuge or other preservation technique and have strictly guided tours. Others offered the alternative of “doing nothing at all” and let the beetles go extinct.

A number of students considered various possible consequences, particularly if the Tiger Beetle goes extinct. These students were focused on the larger ecosystem. “If the beetle is removed from the ecological system, the system will become fragmented and there may be ramifications that were unintentional.” Students were concerned for long-term negative consequences to environmental and human systems. “While the loss of a small, niche population such as the Tiger Beetle may seem insignificant in the grand scheme of nature, we cannot possibly estimate what the cumulative effect of losing multiple species in one area may be.” Some students tied the loss of the Tiger Beetle to possible consequences for agriculture. “Because of the carnivorous nature of the bug, the

sheer volume of pesky insects will be decreased. This will allow for fewer attacks on crops, less disease spread by insects and an overall better life.”

Explanation

Most students cited reasons for accepting their viewpoint, though many who agreed with the original author of the Letter-to-the-Editor merely restated the author’s claims. One student wrote, “the land could be put to much better use that will benefit humans or wildlife,” and proceeded to list the options including development of shopping centers or homes, food production, and refuge for game animals. Students concerned about the money being spent on the Tiger Beetles often cited the national debt of the United States and the lack of money for education, poverty eradication, or healthcare.

Very few students anticipated or responded to possible criticisms of their thoughts. One student arguing to protect the beetle noted, “Some people will try to make the point ‘it’s just a beetle, so what if it disappeared?’ This is a terrible argument and should have no place in such a topic. It is a slippery slope from ‘just a beetle’ to something much bigger that affects many more people. Next thing you know it will be “oh, it’s just a bird or just a deer and so on and so forth.”

While some students used their allotted time to construct a logical argument, many did not. One student wrote, “Farm the ground because no one cares about a measly 205 beetles. Putting those acres back into production will be far more productive than pleasing a few tree huggers and keeping those beetles alive. People need to get a life and worry about things more important than this.”

Self-regulation

When analyzing the critical thinking skill of ‘recognizes need for further inquiry’, we separated this from the evaluation skill of noting when additional information will strength or weaken an argument by looking specifically for students’ discussing their personal need to investigate further. Given that very few students acknowledged ever hearing about the Salt Creek Tiger Beetle previous to the assignment, most students did not acknowledge their ignorance or state that they needed to seek more information. However, a few students did recognize their need to know more before making judgments. “I’ll admit that I don’t know that myself, and would have to know that info before calling the tiger beetle useless to humans.” Many students agreed with the original writer that researchers could not possibly accurately count the beetles. One student noted, “I would like to know more about how we can count and monitor these beetles.”

Very few students reflected upon their own thinking in the piece. A few noted, “I may be wrong” or “it may be me, but...” One student noted, “if scientists were to find some use then I would have to reevaluate my opinion.” This at least demonstrates a willingness to reconsider one’s original opinion. Another student wrote, “However, I also need to look at the other side of the situation and think about the people who have studied these bugs and the bugs themselves.”

A handful of students identified their personal bias, though none did so specifically in the spirit of full disclosure. One student reported actually living next to the beetle habitat. A few students noted they are farmers or ranchers, which influenced

their thoughts on a farmer losing land to preserve the beetle. Only one student identified their major as influencing their opinion, “As an Insect Science major...”

Discussion

Evidence from this study suggests students can perform well on a multiple-choice assessment, but when given a short writing task where they must generate their own responses, most use few critical thinking skills. Over half of the students earned a 75% or higher on the multiple-choice exam. This could be due to the ease of the assessment or because students entering college in 2011 have become accustomed, and likely skilled, at taking multiple-choice exams. Evidence of most critical thinking sub-skills was found throughout the 347 responses, but in all cases, fewer than 15% of students used a particular skill. Overall, results show that students rarely use critical thinking skills when asked to examine and respond to another’s writing. When students did utilize a critical thinking skill, it was not clear whether they did so on purpose. For example, students who self-identified their biases (“I am a rancher, so...”) never indicated they were doing so in the spirit of full disclosure. Given the little information students had about the Salt Creek Tiger Beetle, it was especially disconcerting how few called for more information before making a decision and how few indicated that they, personally, desired further inquiry. Students were happy to argue for a position with little or no previous knowledge of the Salt Creek Tiger Beetle’s plight. Results suggest that students are more skilled at test taking than the actual application of critical thinking skills.

Also, several demographic and other characteristics were examined in relation to critical thinking skills and disposition. Gender and critical thinking disposition were the only two variables related to critical thinking skill. These results are similar to others

finding that females have a higher level of critical thinking skills (Rudd, Baker, & Hoover, 2000), although others have found no relationship between gender and critical thinking skills (Friedel et al., 2008). The strength of a student's environmental views was positively related to all three aspects of critical thinking disposition. Strength of political views was positively related to Innovativeness and Engagement. These results indicate that students who enter college with strong views are more likely to have a disposition to think critically. These students are already passionate about controversial and salient topics, and have likely developed critical thinking skills in response. This may indicate that helping students become passionate, or fostering the passions they develop in high school, will help increase their critical thinking skills. This goal should be relatively easy to accomplish, given the myriad of agricultural and natural resources issues that impact students in their personal and future professional lives.

In this study, gender was related to positively related to Cognitive Maturity and negatively related to Innovativeness. This indicates that females have a higher level of cognitive maturity but males have a higher level of innovativeness. These results are similar to Stedman (2009) that found women had higher levels of cognitive maturity and lower levels of innovativeness.

Interestingly, expected grade was negatively related to all three areas of critical thinking disposition. Given that the course used in the study is a 100-level introductory course, most students may expect it to be easy and therefore expect a good grade, regardless of their interest in thinking critically about the subject.

Future Research

Future research should examine students at multiple points during their college careers. As research has shown, it is not enough to assume students are graduating with necessary skills. Students should be evaluated within classes, pre and post-semester, as well as early in their college career and again before they graduate.

Most of the independent variables evaluated in this study showed no significant relationship with students' entering critical thinking skills or their disposition. If we can learn what influences critical thinking before college, we can better predict students abilities when they first are in our classrooms.

Multi-year studies of freshmen in the same course can demonstrate if students' skills and dispositions vary from year to year or are more consistent. Instructional strategies should vary given the skills and dispositions of students. If students in multiple years have similar abilities and dispositions, instructors can continue to refine developed lessons. If students are varying year to year, it may be more important to get a measure of their critical thinking skills and dispositions each year.

Implications for Practice

Given that employers are demanding college graduates have more than content knowledge and the problems we face in agriculture and natural resources are complex, the need to develop critical thinking in students has never been higher. This study indicates that students are arriving to college with relatively low levels of critical thinking. Although some students can execute some critical thinking skills some of the time, vast improvements are needed to ensure that most students consistently utilize a variety of critical thinking skills. Research has demonstrated specific practices that can

influence the increase of students' critical thinking skills (Quinn, Burbach, Matkin, & Flores, 2009). Instructors need to be cognizant of student disposition and skills when they enter higher education to utilize best practices in classroom pedagogy to ensure students leave with the skills needed for the 21st century workforce. Instructors can utilize rubrics, such as the qualitative codebook developed for this study, to guide activities where students can practice specific critical thinking skills. Each lesson or activity does not need to teach to all skills. One lesson can require students to assess knowledge or opinion claims, later students can formulate their own alternatives, and next practice explaining their reasoning to others.

Conclusion

The need to develop a workforce with the abilities to think critically and apply the skill to agriculture and natural resource issues has never been greater. The environmental problems we face are many and complex. For future professionals to enter the workforce ready to tackle and solve the world's myriad of agricultural and natural resource problems, we must help them to develop and practice critical thinking skills in the classroom. This paper demonstrates that students are quite capable of using critical thinking skills to answer a multiple-choice exam, but less adept at applying their skills in a written assignment. Knowing what abilities freshmen students do and do not possess when entering the classroom, instructors can plan accordingly and use pedagogy demonstrated to increase critical thinking skills.

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CHAPTER IV

Development and validation of a critical thinking assessment for environmental ethics

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Abstract

Future environmental professionals must develop critical thinking skills regarding environmental ethical issues. In turn, higher education instructors need reliable and efficient methods to assess critical thinking in students. In this paper, we report on the creation of two critical thinking assessments for use in environmental, agricultural, and natural resources higher education classrooms. The quantitative and qualitative assessments measure undergraduates' domain-specific critical thinking skills. Future research in the field of critical thinking for environmental studies is also discussed.

Introduction

The 21st century will be a time of great environmental disturbance. The current rate of species extinction is estimated to be 100 to 1,000 times higher than what is considered natural and has likely surpassed a planetary boundary in which species provide ecosystem resilience (Rockstrom et al., 2009). The burning of fossil fuels has increased greenhouse gas concentrations in the Earth's atmosphere, contributing to changes in the planet's climate that bring unknown consequences for human and natural communities (IPCC, 2007). Moreover, agriculture will need to feed 9 billion people using less land while providing greater environmental protection and adapting to a more variable climate (Foley et al., 2011).

These immense environmental issues raise many questions to which there are few clear solutions. Although the above problems present challenges for scientists and practitioners trying to understand the mechanisms behind environmental instability, ethical challenges also arise for individuals, agencies, and governments. For example, whose responsibility is it to reduce greenhouse gases—developing or developed countries? Do citizens in developed countries, who currently consume resources at a much greater rate than people in developing countries, have an obligation to reduce consumption to more sustainable levels? These are just two of many questions environmental professionals must work to resolve.

The ability to think critically about an environmental issue (i.e., to look at the problem from multiple angles, propose hypotheses, consider a variety of solutions, and explain reasoning to others) is essential as the difficult decisions future professionals make will likely affect millions. Given the complex ethical problems environmental

professionals will face in the coming decades, employers are increasingly expecting graduates to possess the ability and desire to think critically (Association of American Colleges and Universities, 2009; Arum & Roska, 2011). Therefore, students must master more than basic facts while in college; students must learn *how* to think, not just *what* to think. To that end, the 2000 National Education Goals Panel (1991) called for an increase in the percentage of college graduates with the ability to think critically. In response, colleges of agriculture, natural resources, and environmental studies are encouraging the development of critical thinking in the classroom, and educators are becoming increasingly aware that students must develop an understanding of the social, political, and ethical implications of their work (Zeidler, Walker, Ackett, & Simmons, 2002).

Definition of Critical Thinking

Critical thinking is often conceptualized as specific skills (Browne & Keeley 1998, Facione, 1990) or as a process or practice (Balin, Case, Coombs, & Daniels, 1999) that is involved in solving problems, formulating inferences, and making decisions (Halpern, 1998). Rudd, Baker, & Hoover (2000) defined critical thinking 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.” In this study, we utilize the critical thinking definition developed through a Delphi project (Facione, 1990). Over the course of a year, forty-six researchers comprised an interactive panel that worked towards a consensus definition of critical thinking. Specifically, six critical thinking skills, and many sub-skills and examples, were developed. The Delphi definition states, “We understand critical thinking to be

purposeful, self-regulatory judgment that results in interpretation, analysis, evaluation, and inference, as well as explanation of the evidential, conceptual, methodological, criteriological, or contextual considerations upon which that judgment is based (p. 2)”.

Critical Thinking Measurements

One key problem for educators is how to best measure students’ critical thinking skills. Assessments must be quick to administer, offer reliable results, and aid in teaching. Some critical thinking experts believe that critical thinking skills can and should transcend subject matter (Halpern 1998, 2001), while others call for a more discipline-specific approach (Balin, 2002; Colucciello, 1997; Willingham, 2007) or even a mixed approach (Ennis, 1985; Facione, 1990; Paul, 1992). Numerous assessments measuring general critical thinking skills exist (Table 1).

Table 1. General Critical Thinking Assessments

Assessment Tool	Citation
Watson-Glaser Critical Thinking Appraisal	1980
The Ennis-Wier Critical Thinking Essay Test	1985
The California Critical Thinking Skills Test: College Level	1990
ICAT Critical Thinking Essay Examination	1996
Cornell Critical Thinking Test	1985

More recently, researchers have considered critical thinking skills for specific disciplines, including nursing (Lunney, 2008; Scheffer & Rubenfeld, 2000), physical education (Tishman & Perkins, 1995), business (Braun, 2004), biology (Bissell & Lemons, 2006), and agriculture (Rudd et al., 2000). However, most areas of study do not have a specific assessment tool to measure critical thinking or changes in students’

critical thinking. Few discipline-specific measures of critical thinking exist because it is often difficult to operationalize critical thinking in the measurement context.

Furthermore, even when such a definition has been determined, the development of valid and reliable measures is time-consuming. As a result, most studies of critical thinking among students utilize a general critical thinking assessment.

The evaluation of critical thinking among students most frequently involves comparing pre- and post-semester article critiques scored according to standards set by the research team (Chen & Lin, 2003; Hofreiter, Monroe, & Stein, 2007). Case studies involving student interviews and classroom observation also have been used to examine pedagogy influencing students' critical thinking skills and dispositions (Tsui 2001, 2002). As with the development of quantitative assessments, most research on qualitative assessments of critical thinking has taken place in the field of nursing. Cise, Wilson, and Thie (2004) developed a self-reflection tool to evaluate changes in critical thinking among nurses. Mishoe (2003) used observations and interviews to identify and describe the critical thinking skills and traits of respiratory therapists.

The literature on evaluating critical thinking using mixed methods is sparse and disparate. Tsui (1999) investigated the impact of college on the development of students' critical thinking skills. Hofreiter et al. (2007) used a mixed methods approach to investigate increases in critical thinking among environmental studies students in a forest issues course.

Purpose

Future environmental professionals will be asked to help society deal with difficult scientific and ethical issues stemming from biodiversity loss, climate change, and

agricultural production impacts, among others. Given the time and resource constraints faculty face, the lack of assessments accurately measuring critical thinking ability is not surprising (Aviles, 1999; Facione, 1990; Paul, Elder, & Bartell, 1997). Therefore, it is essential to create tools that allow instructors to measure students' critical thinking in regards to environmental issues. The purpose of this study was to create and test quantitative and qualitative methods assessing critical thinking about environmental ethical issues among undergraduate students.

Methods

Development of Quantitative Measure

The purpose of the quantitative measure was to assess critical thinking skills applied to environmental ethics. To that end, researchers developed thirty-six items, each targeting one of three critical thinking skills, using the method employed by Facione (1990). Specifically, 12 items targeted Analysis, 12 items targeted Interpretation, and 12 items targeted Evaluation. Items were written using terminology that was applicable to undergraduate students. Each question involved the application of one critical thinking skill to an environmental ethical issue such as reducing greenhouse gas emissions, biodiversity loss, pesticide use, recycling, and genetically modified organisms in agriculture. Although questions utilized the context of environmental ethical issues, they were written such that content knowledge was not required to answer the question correctly. All items were multiple-choice with three possible answers.

Next, the face validity of the items was evaluated. Six experts—faculty from three universities in disciplines including leadership, environmental studies, natural resources, and agronomy—were asked to identify the critical thinking skill targeted by each

question using a list of possible skills and corresponding examples. Experts were also asked to rate the difficulty of each item on a scale ranging from “not at all difficult” (1) to “very difficult” (10) and to report how long it took them to complete the entire assessment. Most experts reported taking at least one hour to answer all of the questions. Items with the highest face validity of at least 80% expert agreement on difficulty were retained. Ultimately, the measure consisted of eighteen items (Table 2).

To further evaluate the quality of the eighteen-item measure, a field pre-test was conducted. The pre-test instrument was administered to 285 students in an introductory agriculture and natural resources course at a large land-grant university in the Midwest. Students were in one of three sections of the 2010 fall semester course. Participants completed the instrument outside of class using QualtricsTM, a web-based data collection tool. Students were expected to complete the assessment in approximately 20 minutes. Thirteen students’ responses were removed from analysis given their completion time was under ten minutes and a close look at their answers revealed the test was not taken seriously. For example, these students answered only ‘A’ or only ‘C’ for all questions and/or spent less than five minutes on the entire assessment, including the consent letter, demographic information, critical thinking disposition, and the 12-question multiple-choice exam.

Development of Qualitative Measure

Although a valid, multiple-choice instrument is easy to administer, there are aspects of critical thinking that cannot be elucidated with such an assessment. It is equally essential to analyze students’ use of critical thinking in a real-world scenario and to understand the process undertaken when asked to use such skills. To do so, a

qualitative measure is more appropriate. Article critiques are a frequently used tool to assess students' critical thinking abilities. Rubrics allowing instructors or researchers to assess students' writing have been developed by Hofreiter et al. (2007) and Irani et al. (2007) around the critical thinking constructs of Facione (1990). However, the rubrics have most often been used to convert students' written work into a numerical score. Ennis (1993) advocates this approach for small sample sizes. We contend that qualitative methods can also be used for larger classes, if students' work is not translated into a score, but used instead to find examples of how students are applying critical thinking skills.

To ascertain how students use critical thinking skills in an environmental context, researchers created a qualitative codebook (Creswell, 2009) from the six critical thinking skills created by the Delphi study (Facione, 1990). Specific sub-skills were included that are to be expected when writing an article critique regarding an ethical issue. For example, the Analysis skill of "comparing and contrasting divergent viewpoints" was included while the Analysis skill of "breaking up a complicated assignment into smaller, more manageable tasks" was not. Initially, 25 codes under 6 critical thinking skills were created.

Students in the same introductory agriculture and natural resources course, in the fall of 2011, were given an actual letter-to-the-editor, written to the local paper, about a controversial endangered species and basic information on the species and threats to its habitat. The local community is currently in a heated ethical debate regarding plans to protect the endangered insect. During class time, students were asked to write a minimum of ten sentences in response to the article.

Results

Quantitative Measure

Two-hundred and seventy two student responses were used in the analysis. The average age of students was 19 years. Seventy-eight percent were freshmen, 15% were sophomores, 6% were juniors, and only 1% seniors. Fifty-six percent were male and 44% were female.

Using Item Response Theory (IRT) framework, we evaluated the properties of the eighteen-item measure. IRT describes the probability that a student will choose a particular response to a test item as a function of 1) characteristics of the item (e.g, difficulty, discrimination) and 2) the trait level of the student (e.g., critical thinking) (de Ayala, 2009). An item's difficulty is defined as the trait level at which a student has a 50% chance of answering the item correctly. An item's discrimination characterizes how well the item discriminates among students possessing varying levels of the trait. Such models are often used to describe the probability that students will select the correct answer to a multiple-choice item. Student responses were coded as either correct or incorrect to facilitate the use of dichotomous IRT models.

To determine whether items differed in discrimination in addition to difficulty, one- and two-parameter models were compared. In the one-parameter model (1PL), items differ only in their difficulty and thus all item characteristic curves have the same slope. In a two-parameter model (2PL), items also differ in their discrimination and thus their item characteristic curves have different slopes. For example, an item with a more flat item characteristic curve does not discriminate well among students of different abilities. First, both one- and two-parameter modes were tested for a data best fit. In a

one-parameter model, items differ only in their location or difficulty. In a two-parameter model, items also differ in their discrimination. A two-parameter model fit the data best as indicated by the significant change in the -2 log likelihood (Δ -2LL = 82.45, Δ df= 17, $p < .001$). Furthermore, the two-parameter model had smaller information criteria values than the one-parameter model—another indication of superior model fit (Table 2).

Having established that a two-parameter model fit the data best, the dimensionality of the measure was assessed. Again, as indicated by the non-significant change in the -2 log likelihood, the one-dimensional model fit the data best (Δ -2LL = 0.03, Δ df= 1, $p = .862$). Furthermore, the one-dimensional model had smaller information criteria values (Table 3). Six items with flat item characteristic curves were removed from the assessment, leaving 12 items (Appendix 1).

Table 2. Model fit statistics

	-2 Log Likelihood	df	AIC	BIC	saBIC
1 dim 1PL	5647.61	19	5685.61	5755.07	5694.82
1 dim 2PL	5565.16	36	5639.13	5774.40	5657.07
Difference	82.45	17			
1 dim 2PL	5565.16	36	5637.16	5768.77	5654.61
2 dim 2PL	5565.13	37	5639.13	5774.40	5657.07
Difference	0.03	1			

Table 3. Information criteria for one-dimensional model

item	discrimination	difficulty	intercept	STDYX loading
1	0.357	-0.076	-0.046	0.317
2	0.647	-1.086	-1.195	0.519
3	0.382	-2.021	-1.311	0.337
4	1.044	-2.051	-3.64	0.699
5	0.998	-1.229	-2.085	0.683
6	0.822	-1.723	-2.406	0.61
7	0.689	-1.043	-1.222	0.543
8	0.877	-1.292	-1.927	0.635
9	0.815	-1.325	-1.836	0.607
10	0.893	-1.44	-2.187	0.642
11	0.51	-0.632	-0.548	0.431
12	0.89	-1.031	-1.56	0.641

Qualitative Measure

Three hundred forty seven students submitted a written response to the letter-to-the-editor. Responses were imported into MaxQDA for qualitative analysis. Following Facione (1990) and Hofreiter et al. (2007), the six critical thinking skills and sub-skills/examples were used to create a qualitative codebook. A total of 25 specific critical thinking skills were put into the codebook.

Data analysis followed qualitative research procedures (Creswell, 2009). First, all responses were read to get a sense of students' thoughts. Next, each response was read individually and sentences that demonstrated use of a critical thinking skill were coded into the predetermined categories. While coding, it became apparent that some critical thinking skills overlapped. For example, it was often difficult to decide if a student's statement should go into Analysis- 'identifies specific phrases or sentences in the text as relevant or irrelevant' or Evaluation- 'judges the strength of the original

argument's premises and assumptions' or Evaluation- 'assesses the credibility of supporting information or evidence'. Therefore, only one of the skills was retained as a possible code and all sentences originally coded into one of the three were re-coded into the remaining code. Creswell (2009) states, even when using a predetermined codebook, codes can evolve and change during the study based on close analysis of the data. The goal was to elucidate the most simple and effective categories for coding student responses. From 25 initial codes, 15 remained (Table 4). The codebook for qualitative analysis allows us to see if and how students are using specific critical thinking skills.

Table 4. Final items for qualitative assessment of student writing

Skill	Sub-skills
Interpretation	summarizes the author's words in own words uses an example to explain
Analysis	defines terms compares and contrasts divergent viewpoints analyzes the overall structure of the argument
Evaluation	assesses the credibility of supporting information or evidence assesses if any additional information might strengthen or weaken the argument
Inference	derives plausible conclusions formulates alternatives for solving a problem discusses possible consequences from different choices
Explanation	gives reasons for accepting a claim anticipates and responds to possible criticism or others' opinions
Self-regulation	recognizes need for further inquiry reflects upon and justifies own thinking process identifies personal biases

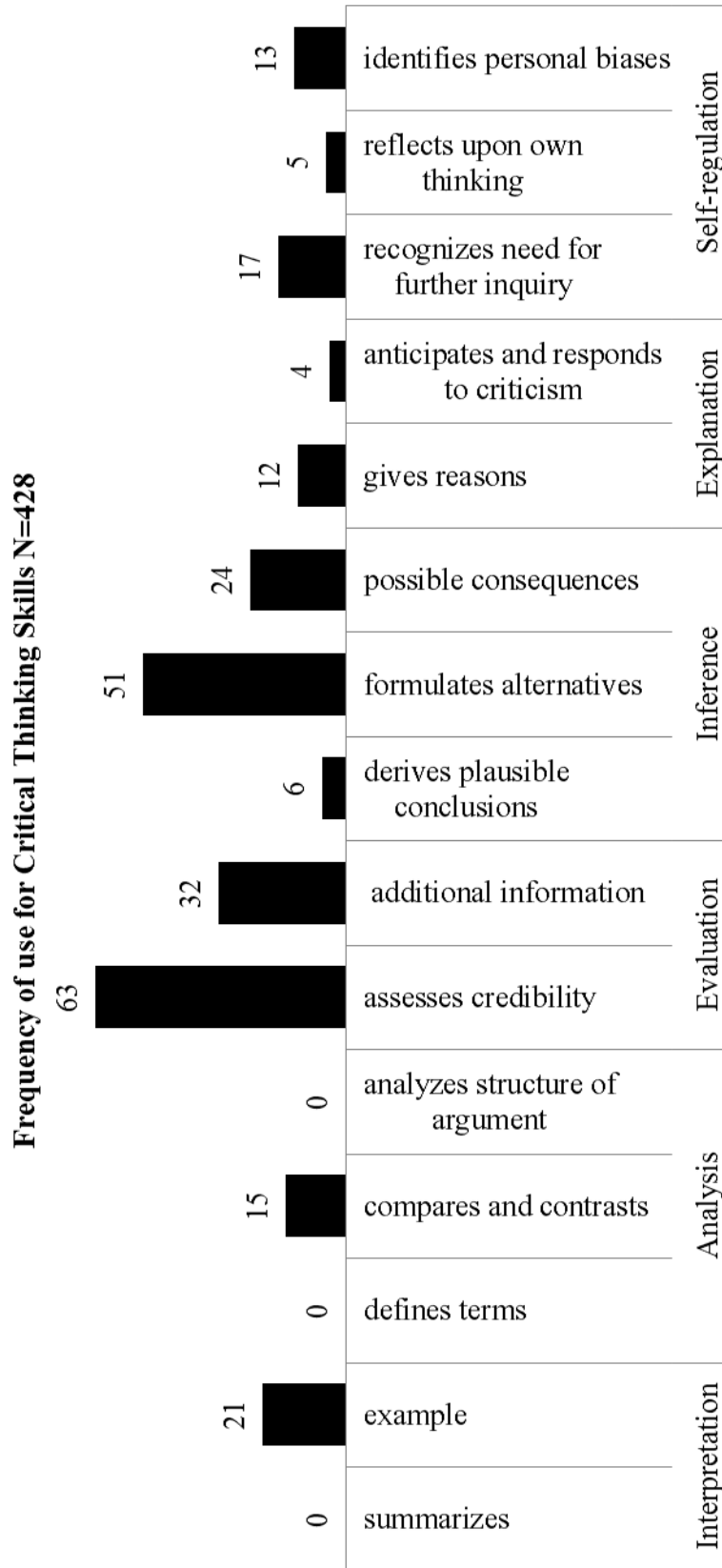


Figure 1. Frequency of use for each critical thinking skill.

Discussion

The importance of teaching critical thinking to future environmental professionals cannot be denied. The problems we face in the coming century will be many, complex, and interconnected. In addition, many of the decisions professionals make will have an ethical component. Decision makers and management professionals will be dealing with trade-offs, various stakeholder opinions, and have to make choices with no easy answers that may negatively affect different groups of people or ecosystems. Therefore, as instructors, we must proactively teach critical thinking skills. In turn, this calls for valid and reliable ways to measure critical thinking regarding environmental ethical issues. The quantitative critical thinking instrument developed in this study is a valid and reliable multiple-choice assessment that can be used without inducing survey fatigue in students.

The assessment can be used at both the beginning and end of semesters to gauge students' incoming ability and/or their change in ability after course instruction. Instructors wishing to gain a fuller understanding of students' critical thinking can use the rubric to evaluate students' written response to an environmental ethical issue.

This assessment method can be invaluable in determining students' ability to apply critical thinking to a real-world scenario. The rubric developed for evaluating students' responses allows for a reasonably quick gauge of students' ability. The qualitative codebook provides information in multiple ways. First, an instructor can easily see which skills students are using voluntarily and which they are not. Second, instructors can see how students are using a particular critical thinking skill and whether or not they are using the skill in a manner that is satisfactory for the level of course and student ability. Used together, the two measures will give instructors a better

understanding of students' skill level and can be used to guide course content, activities, and future evaluation.

Future Research

The quantitative assessment developed here, though valid, should be made more difficult to truly assess students' critical thinking ability regarding environmental issues. Questions should be modified, or other more difficult questions should be substituted until questions cover a broader range of student ability. Although the instrument may need to be more difficult for college students, it may be of use in secondary classrooms or with the public. Future research should also investigate any differences that appear in students' abilities on quantitative and qualitative measures. Much work exists at the intersection of environmental issues and teaching of critical thinking. Best practices for teaching should be developed that can guide educators in curriculum development and classroom activities.

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CHAPTER V

Measuring Improvements in Students' Critical Thinking about Environmental Ethics:
A Mixed Methods Triangulation Study

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Abstract

This study evaluates changes in students' critical thinking regarding environmental ethical issues and describes student use of critical thinking skills in an introductory agriculture and natural resources course using a triangulation convergence mixed methods approach. Quantitative data was gathered through a 12-item multiple-choice critical thinking assessment designed specifically about environmental ethics. The assessment was administered pre and post-semester. Qualitative data was garnered through a pre- and post-semester writing assignment. McNemar's test showed no statistically significant change for ten of twelve questions. However, over three semesters, 252 of 548 students (46%) improved their score by at least 1 point from the pre- to the post-test. Qualitative results support quantitative findings. Students utilized few critical thinking skills in either the pre- or post- writing assignment.

Introduction

The environmental problems society is facing in the 21st century are varied, wide spread, and affect billions of humans as well as natural communities. Environmental, agricultural, and natural resource professionals will be leaders at the forefront of efforts to address these challenges, working to help humanity mitigate and adapt to changing environments. Today's students, our future leaders and professionals, must gain a wide variety of knowledge, skills, and behaviors while in college so they are prepared to actively engage in solving environmental, social, and economic consequences of human actions. Although sufficient content knowledge is essential to a graduating student, it is evident that content knowledge alone is insufficient to address pressing environmental problems. A properly trained student will graduate with professional capacities reaching beyond technical expertise (Jordan, Bawden, & Bergmann, 2008). One skill crucial to effective environmental leadership will be the ability to think critically about the ethical consequences of policy, economic systems, and individual human behaviors on the environment (Quinn, Burbach, Matkin, & Flores, 2009).

The need to increase students' critical thinking skills was identified as a key goal in the last three decades (Association of American Colleges, 1985; National Commission of Excellence in Education, 1983; National Education Goals Panel, 1991). Thus, colleges and universities increasingly encourage the development of critical thinking in their students. However, overwhelming evidence indicates that students are not gaining the necessary skills and faculty are not teaching to a level necessary to impart critical thinking skills (Browne & Freeman, 2000; Handelsman et al. 2007). Researchers have consistently found low levels of critical thinking in college students (Keeley, Browne, &

Kreutzer, 1982; Zascavage, Masten, Schroeder-Steward, & Nichols, 2007).

Consequently, students are frequently entering the workforce lacking critical thinking skills demanded by today's employers (Association of American Colleges and Universities 2009; Casner-Lotto, Barrington, & Wright, 2006; U.S. Department of Education, 2006)

However, some researchers have demonstrated that instruction in critical thinking can increase students' skills (Burbach, Matkin, & Fritz, 2004; Gadzella & Masten, 1998; Halpern, 1998; Hofreiter, Monroe, & Stein, 2007). Specific activities, such as writing assignments, have been shown to increase students' critical thinking skills (Chen & Lin, 2003; Tsui, 2002; Powell, 2009). In addition, journaling (Jones & Brown, 1993; Lizzio & Wilson, 2007) and other opportunities for self-reflection (Thompson, 1998, Grossman, 2009) can positively influence critical thinking. A meta-analysis of 117 empirical studies showed that teaching critical thinking skills, in general, have a positive impact on critical thinking skills, with a mean effect size of 0.34 (Abrami et al. 2008). The largest effect sizes came when instructors received specialized training in teaching critical thinking (Martin, Craft, & Sheng, 2001; VanTassel-Baska, Zuo, Avery, & Little, 2002).

This study sought to examine critical thinking skill regarding environmental ethical issues in environmental, agricultural, and natural resource students at a large mid-west research university. Students were examined both pre- and post-semester with quantitative and qualitative instruments.

What is Critical Thinking?

Researchers have offered many and diverse definitions of critical thinking (Ennis, 1985; Facione, 1984; Paul, 1983; Rudd, Baker, & Hoover, 2000; Watson & Glaser, 1980). Paul (1993) suggested “critical thinking is the art of thinking about thinking while you’re thinking so to make your thinking more clear, precise, accurate, relevant, consistent, and fair” (p.136). The National Council for Excellence in Critical Thinking (1987) defined critical thinking as, “the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action.”

One of the most commonly cited definitions of critical thinking was created through a Delphi process with experts from several disciplines. A multidisciplinary team of forty-six experts developed a consensus definition and conceptualization of critical thinking stating, "We understand critical thinking to be a purposeful, self-regulatory judgment which results in interpretation, analysis, evaluation and inference as well as explanation of the evidential conceptual methodological, criteriological, or contextual considerations upon which that judgment was based" (Facione, 1990). Moving beyond a mere definition of critical thinking, the Delphi Project experts created a list of six critical thinking skills; interpretation, analysis, evaluation, inference, explanation, self-regulation. Interpretation is the ability to comprehend and express meaning of a wide variety of experiences, beliefs, procedures, and rules. Analysis is identifying the relationship between statements, questions, concepts or descriptions to express beliefs, judgments or reasons. Evaluation is the ability to assess the credibility of statements and

representations of others as well as assessing the logical strength of statements, descriptions or questions. Inference is defined as the ability to identify and secure elements needed to draw reasonable conclusions and/or hypotheses based on facts, judgments, beliefs, principles, concepts or other forms of representation. Explanation is the ability to state and justify the results of one's reasoning. Self-regulation is the ability to monitor one's personal cognitive activities and applying analysis and evaluation to one's own judgments with a view to question, confirm, correct one's results. For the purpose of this study, I utilize the Delphi definition and the six skills of critical thinking to guide the measurement of student skills. This list, along with explanations and examples, has helped to remove some challenge of understanding and measuring a nebulous concept.

Environmental Ethics and Critical Thinking

In addition to developing general critical thinking skills, it is important to develop subject area critical thinking skills (Ennis, 1990). Science educators are becoming aware that students must develop an understanding of the social implications of science including ethical and political affairs (Zeidler, Walker, Ackett, & Simmons, 2002). However, ethics have been excluded or marginalized in traditional science education (Hargrove, 2000; Hodson, 2003). This is a dangerous omission. Students who can think critically about their subject but do not understand the ethical implications of their work run the risk of not understanding how their decisions and behavior might affect others (Paul & Elder, 2009).

Due to the epistemological diversity in knowledge claims, environmental studies, agricultural, and natural resource students must prepare to deal with a wide variety of

people with opinions that are not neatly classified into ‘right and wrong’, ‘for or against’. Academics, policy makers, concerned citizens, and others make knowledge and value claims about environmental issues. Students need to think critically about the arguments and evidence presented by various stakeholders. This need for thinking critically about environment issues includes analysis of both quantitative data used to support claims and ethical arguments.

One would be hard pressed to find an environmental or agricultural issue that does not have an ethical component. Decisions regarding environmental management, conservation, life style choices, laws and regulations, and activism all contain ethical dilemmas. For example, environmental professionals must understand the science of climate change, but they must also be able to articulate and understand the contentious political opinions of developed and developing countries as to who has the responsibility to reduce green house gas emissions. Again, professionals must understand the laws that govern protection of endangered species, but must also have the ability to consider the economic and social concerns of communities that are regulated to protect said species. These examples help to demonstrate why the ability to think critically may be more important in environmental studies than in other disciplines (Jones & Merritt, 1999). Therefore, the development of environmental and agricultural scientists, professionals, and leaders who can think critically about ethical issues is paramount to addressing environmental problems.

Measuring Critical Thinking

One difficulty faced by researchers and educational administrators is the measurement of critical thinking. Both philosophical and practical problems arise.

Norris (1989) notes that because the degree of generalness or specificity of critical thinking has not been resolved, assessing critical thinking remains difficult. General measurements of critical thinking can be time consuming and expensive to administer. In addition, few disciplines have accessible and valid measurements to use in assessing students. The time required to teach all required content knowledge can preclude using class time for an additional assessment. Although not a regular occurrence due to reasons mentioned above, instructors and scholars have worked to measure student critical thinking and dispositions, and changes in critical thinking through both quantitative and qualitative measurements.

Tools to measure critical thinking are numerous. Quantitative assessments to measure critical thinking skills in adults predominately focus on general skills (Ennis & Millman, 1985; Facione, 1990; Watson & Glaser, 1980). However, these general assessments are not often used in the classroom given their length and cost to administer. Instructors and researchers have found avenues to measure critical thinking in the classroom. A popular method of classroom critical thinking evaluation is to have students complete a pre- and post- semester article critique (Chen & Lin, 2003; Hofreiter et al., 2007). Student essays are scored according to standards set by the research team. Case studies including interviews and classroom observations have been used to examine pedagogy that influences students' critical thinking skills and dispositions (Tsui 2001, 2002).

As with quantitative assessment, most work on qualitative assessment of critical thinking skill is in fields outside environmental topics. Cise, Wilson, Connie, and Thie (2004) developed a critical thinking self-reflection tool for nurses to evaluate changes in

critical thinking. Mishoe (2003) used observations and interviews to identify and describe the critical thinking skills and traits of respiratory therapists.

The literature on critical thinking using mixed methods is sparse and disparate. Tsui (1996) investigated the impact of college on the development of students' critical thinking skills. Kwon (2008) investigated the associations between critical thinking dispositions and library anxiety in undergraduate students. Interestingly, Hofreiter et al. (2007) used a mixed methods approach to investigate critical thinking development in environmental studies students in a forest issues course.

Although there has been some academic discussion regarding critical thinking and environmental ethics (Casari & Johnson, 1995; Jungst, Thompson, & Atchison, 2003; Jones and Merritt, 1999a,b; Hofreiter et al., 2007), a search in relevant academic journals and Google Scholar turned up no discussion or assessment tools to specifically measure critical thinking in the context of environmental ethics.

Purpose

This mixed methods study (Creswell & Plano-Clark, 2007) addresses application and changes in students' environmental ethics critical thinking skills over the course of a semester.

Quantitative research hypothesis:

1. Students' ability to think critically about environmental ethics issues will increase from the beginning to the end of the semester.

Quantitative research question:

1. What is the relationship between students' characteristics (ie. gender, age, strength of religious beliefs) and their pre semester critical thinking skills? Post-semester critical thinking skills? Change in critical thinking skills?

Qualitative research central questions:

1. What critical thinking skills are students using in writing assignments?
2. How does students' use of critical thinking skills vary from early semester through late semester?

Methods

A triangulation mixed methods design (Creswell & Plano-Clark, 2007) was used to collect and analyze complementary data on the topic. In this study, a 12-item multiple-choice assessment was administered pre- and post-semester (Chapter 4). Concurrent with this data collection, students completed a written assignment for qualitative assessment. The purpose for collecting both quantitative and qualitative data was to utilize the strengths of both forms of research to allow comparison of results.

The use of mixed methods is increasing in the social sciences. Not shackled to one worldview or research paradigm, mixed methods research is driven by anticipated consequences (Cherryholmes, 1992). Mixed methods researchers seek to draw on the strengths of both quantitative and qualitative methods to employ all available tools to address their research question (Creswell & Plano-Clark, 2007; Johnson, Onwuegbuzie, & Turner, 2007). The use of quantitative assessments can tell us if students possess critical thinking skills, but does not take into account important aspects of critical thinking such as the depth of student experiences or their use of skills.

As educators, we want to know if our students are gaining the critical thinking skills we teach. Furthermore, we want our students to *use* their skills. It is important to understand if and how students are engaging in the process of critical thinking in their classes and with their peers. Creswell and Plano-Clark (2007) note that mixed methods allows us to measure trends and outcomes (are students gaining critical thinking skills?) while at the same time examine the context and process (how are students using critical thinking skills in the classroom?). A mixed methods approach to research on critical thinking allows us to measure skills as well as assess the use of skills. This has the anticipated consequence of, over time, improving instruction to ensure students are leaving our institutions prepared to tackle complex environmental ethics problems.

This study utilized a triangulation convergence model. The use of multiple measures, and understanding how they converge, offers researchers the opportunity to examine a phenomenon from several perspectives to augment previous understanding and allow new or deeper dimensions of a phenomenon to appear (Jick, 1979). Following recommendations for this design, quantitative and qualitative data were collected and analyzed separately and the results are converged during interpretation and presented with the results (Creswell & Plano-Clark, 2007). Figure 1 presents a visual model of the triangulation design procedure.

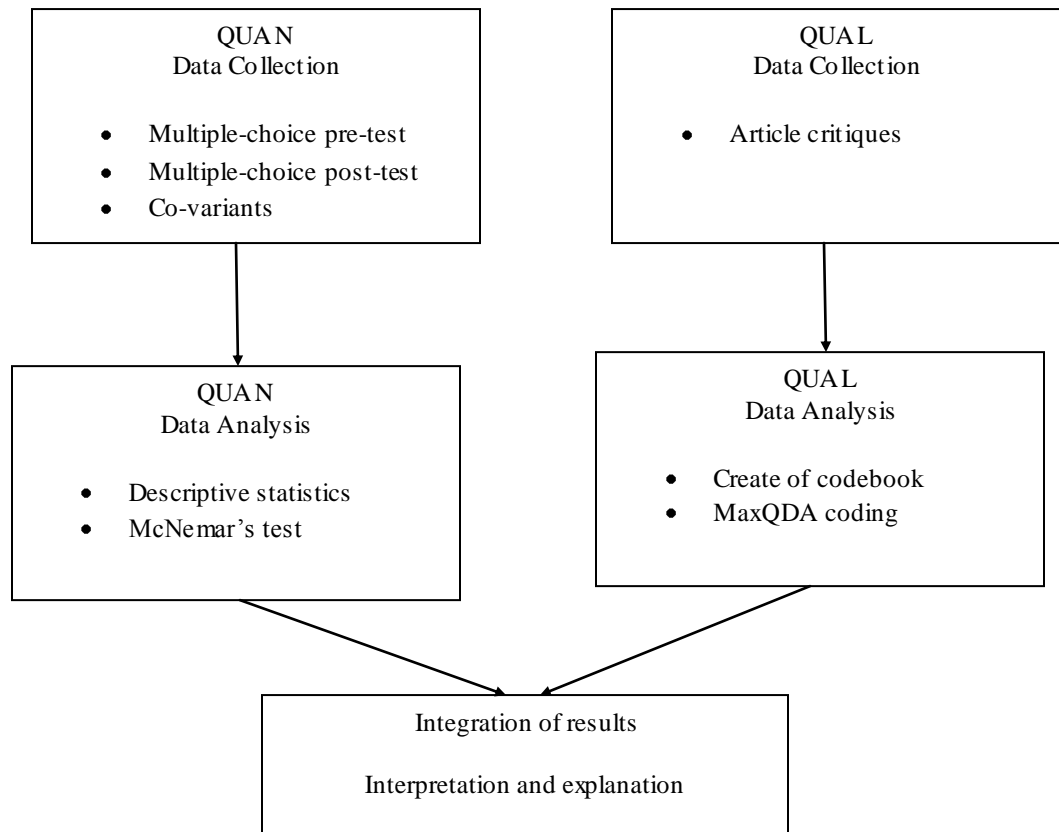


Figure 1: Visual Representation of Research.

Explicitly Teaching Critical Thinking in the Classroom

During three semesters in 2010 and 2011, students in an introductory agriculture and natural resources course at a large mid-western university participated in this study. All students attended a weekly lecture and a one-hour recitation. Each semester, recitation sections had approximately 25 students taught by a graduate student or faculty member. Two early recitation days were devoted to the concept of critical thinking and its importance in education. For the rest of the semester, students engaged in three modules focused on pertinent environmental topics. Each module consisted of three class periods. Students completed readings and a pre-class assignment for each class-period.

The first class-period in each module was devoted to quantitative methods such as interpreting or creating graphs. The second class-period was focused on ethical issues. Specific critical thinking skills were taught in the context of an activity that asked students to make team decisions on an issue related to the larger topic. For example, in the biodiversity loss module, students learned to identify argument conclusions, emotional trigger words, and ethical theories used in arguments for and against Yellowstone bison being on Ted Turner's ranch. Team-based learning was employed in recitations and students worked in a competitive team environment that promoted both individual and team accountability (Michaelsen, Bauman, Knight, & Fink, 2004). The last class-period of each module was devoted to a team project that required students to integrate the quantitative skills and the ethical critical thinking skills. Therefore, students spent two days per unit learning and practicing critical thinking on environmental ethical issues.

The recitation curriculum was designed to overtly teach critical thinking skills about environmental ethics. Recitation instructors received training in critical thinking before the semester and before each of the three modules; biodiversity loss, climate change, and agroecology. The importance of explicitly teaching critical thinking has been shown (Beyer, 1987; Friedel et al., 2006; Hofreiter et al., 2007), therefore recitation instructors informed students each time a specific critical thinking skill was taught.

Quantitative Measures

The Environmental Ethics Critical Thinking Assessment (Chapter 4) is a 12-item multiple-choice test created to measure critical thinking about environmental ethics (Appendix A). A field pre-test was administered to 285 students through Qualtrics.

Items were validated using Item Response Theory. The resulting assessment is a two-parameter ($\Delta\text{-2LL} = 82.45$, $\Delta\text{df} = 17$, $p < .001$), one-dimensional ($\Delta\text{-2LL} = 0.03$, $\Delta\text{df} = 1$, $p = .862$) model.

The assessment was completed outside of class time. In addition, items were added to the measure as predictors of students' critical thinking ability. These included, students' grade point average, age, gender, year in school, self-rated strength of political, religious, and environmental views, the number of previous courses taken on similar topics, the time students have spent outside of the United States, and self-ratings of leadership in the classroom, in extra-curricular activities, and in a social group. Students' critical thinking disposition was also assessed pre- and post-semester using the University of Florida–Engagement, Maturity, and Innovativeness assessment (UF-EMI).

Assessment results were transferred into SPSS. Means, frequencies, and standard deviations were run for all relevant items. A McNemar's test for dichotomous outcome in matched samples was run to compare change in students' pre- and post- assessment scores. Regression analysis was performed on all independent variables with pre-test scores, post-test scores, and change in scores.

Qualitative Measures

Article critiques are frequently used to assess students' critical thinking (Chen & Lin, 2003; Hofreiter et al., 2007). In this study, students responded to a letter-to-the-editor regarding a local controversial endangered species during class time. The community surrounding the university is in an on-going heated debate regarding plans to protect the endangered species. During class time in the fall of 2011, students spent 25 minutes writing a minimum of ten sentences in response to the letter-to-the-editor. All

responses were entered into QualtricsTM and transferred into MaxQDA for analysis. A qualitative codebook based upon the six critical thinking skills presented by the Delphi study of Facione (1990) was developed for the study (Table 1). In addition, the codebook developed by Hofreiter et al. (2007), also based on Facione (1990), was used as a guideline. Each response was read and sentences or ideas that demonstrated use of a critical thinking skill were coded into the predetermined categories. The critiques were not given an individual score, as has been utilized to evaluate critical thinking in past studies (Hofreiter et al., 2007). Rather, the purpose was to gain an overall understanding of how (and how often) students used, or failed to use, each of the critical thinking skills.

Table 1: Qualitative codebook for critical thinking skills

Skill	Sub-skills
Interpretation	summarizes the author's words in own words uses an example to explain
Analysis	defines terms compares and contrasts divergent viewpoints analyzes the overall structure of the argument
Evaluation	assesses the credibility of supporting information or evidence assesses the credibility of views or opinions assesses if any additional information might strengthen or weaken the argument
Inference	derives plausible conclusions formulates alternatives for solving a problem discusses possible consequences from different choices
Explanation	gives reasons for accepting a claim anticipates and responds to possible criticism or others' opinions logically communicates thinking
Self-regulation	recognizes need for further inquiry reflects upon and justifies own thinking process identifies personal biases

Results

Quantitative Results

Participants were 548 students, 17 years of age or older enrolled in an introductory course on agriculture and natural resources during three semesters in 2010 and 2011. Of the 548 participants, 304 were male and 244 were female. Four-hundred and eighteen were freshman, 82 sophomores, 35 juniors, and 13 seniors. Ages ranged from 17 to 43 with the vast majority (82.3%) being 18 or 19 years old. Students participated in 29 different majors including Animal Science (73 students), Fisheries and Wildlife (74 students), and Veterinary Science (56 students). Most students had no previous courses in ethics or environmental ethics. Only 25.5% reported participating in one or more ethics classes. Only 16.8% of students reported participating in one or more

previous environmental ethics course. More students had previously taken a course in logic or critical thinking (50.8%), agriculture (47.6%) and natural resources (47.6%) compared to an ethics course or an environmental ethics course.

Quantitative Hypothesis: Students' ability to think critically about environmental ethics issues will increase from the beginning to the end of the semester.

In all, 252 students (46%) improved their score by at least 1 point in the overall assessment from the pre to the post-test (Table 2). However, the McNemar's test showed no change for ten of twelve questions and a significant change for two questions, numbers 3 and 10 (Table 3). Question 3 saw a significant positive change while Question 10 saw a significant negative change.

Table 2: Change in total number correct

Total number of answer improvement	Number of students
1	118
2	67
3	24
4	26
5	10
6	4
7	3

Table 3. Paired Sample McNemar's Test

Question	Number who answered the question correctly		Difference	Significance, * $p < .05$
	Pre	Post		
1	430	424	6	0.79
2	478	480	-2	0.95
3	460	496	-36	0.02*
4	455	448	7	0.73
5	340	338	2	0.97
6	454	432	22	0.23
7	464	448	16	0.37
8	524	522	2	0.94
9	298	326	-28	0.26
10	407	326	81	0.00*
11	499	520	-21	0.13
12	403	406	-3	0.92

Quantitative Research Question: What is the relationship between students' characteristics (gender, age, strength of religious beliefs etc.) and their pre semester critical thinking skills? Post-semester critical thinking skills? Change in critical thinking skills?

The step-wise regression for Pre-critical thinking skills score showed that students' critical thinking disposition ($\beta = .052$, $p < .000$) was positively related to skills. Students with a greater disposition to think critically scored higher on the critical thinking assessment. In addition, gender was a significant predictor as females scored higher on the assessment ($\beta = 1.01$, $p < .000$). Students who spent more time on the assessment ($\beta = -2.114$, $p < .000$), had previously taken courses in agriculture ($\beta = -.461$, $p < .000$), and expected a higher grade ($\beta = -.821$, $p < .000$), performed less well on the exam.

Table 4. Step-wise Regression for Pre Critical Thinking Skills (N= 548)

Variable	B	SE B	β
Constant	3.898	1.184	
Disposition	0.052	0.010	0.203
Gender	1.010	0.198	0.201
Time on assessment	-2.114	0.452	-0.184
Agricultural classes	-0.461	0.122	-0.149
Expected grade	-0.821	0.239	-0.139

$R^2 = 0.42$, $F = 23.08$, $p < .05$

Excluded variables: major, year, age, GPA, strength of political views, strength of religious views, strength of environmental views, previous ethics classes, previous environmental ethics classes, previous critical thinking classes, previous natural resource classes, time spent out of the U.S., self-rating of in-class leadership, self-rating of extra-curricular leadership, self-rating of social group leadership.

The step-wise regression for Post-critical thinking skills score showed that students' critical thinking disposition at the end of the semester ($\beta = .051$, $p < .000$) continued to positively predict skills. In addition, gender remained positively related to skills ($\beta = .937$, $p < .000$). Students who expected a higher grade at the end of the semester ($\beta = -.870$, $p < .000$), spent more time on the assessment ($\beta = -1.322$, $p < .005$), and had previous agriculture classes ($\beta = -.360$, $p < .005$), scored lower on the post-semester critical thinking assessment. Again, students who spent less time on the assessment, had previous agriculture classes, and had a higher expected grade did less well on the exam.

Table 5. Step-wise Regression for Post Critical Thinking Skills (N= 548)

Variable	B	SE B	β
Constant	4.975	0.981	
Disposition	0.050	0.009	0.231
Gender	0.905	0.192	0.182
Time on assessment	-0.138	0.442	-0.121
Agricultural classes	-0.360	0.118	-0.117
Expected grade	-0.906	0.148	-0.239

$R^2 = .469$, $F = 30.324$, $p < .05$

Excluded variables: major, year, age, GPA, strength of political views, strength of religious views, strength of environmental views, previous ethics classes, previous environmental ethics classes, previous critical thinking classes, previous natural resource classes, time spent out of the US, self-rating of in-class leadership, self-rating of extra-curricular leadership, self-rating of social group leadership.

The step-wise regression for change in critical thinking skills score showed that students' total score on post-assessment ($\beta = .330$, $p < .000$), and their expected grade at the end of the semester ($\beta = .452$, $p < .000$), were significant predictors of students' change in critical thinking. Students who scored well on the post exam had a higher change in their critical thinking score. In addition, students' who had a higher expected grade had a greater change in their pre-to post-semester scores.

Table 6. Step-wise Regression for change in Critical Thinking Skills (N= 548)

Variable	B	SE B	β
Constant	-3.330	0.405	
Expected grade	0.452	0.122	0.153
Score on post test	0.330	0.032	0.423

$R^2 = .406$, $F = 53.363$, $p < .05$

Excluded variables: major, year, age, GPA, disposition, gender, strength of political views, strength of religious views, strength of environmental views, previous ethics classes, previous environmental ethics classes, previous agricultural classes, previous critical thinking classes, previous natural resource classes, time spent out of the US, self-rating of in-class leadership, self-rating of extra-curricular leadership, self-rating of social group leadership.

Qualitative Results

Qualitative research central questions:

1. What critical thinking skills are students using in written assignments?
2. How does students' use of critical thinking skills vary from early semester through late semester?

In both the pre semester and post semester assignment, students rarely utilized critical thinking skills in their responses. However, the skills used represent a variety of critical thinking skills. In neither writing assignment did over 20% of students use a particular critical thinking skill (Table 7).

Pre Semester Skills

At the beginning of the semester, the skills of Evaluation and Inference were used most frequently. Sixty-three students (18.2%) assessed the credibility of the original author. For example, "the comment about rounding the beetles up and putting them in their own backyards shows the writer's ignorance. The writer completely ignored the fact that tiger beetles are wild animals with a specific habitat." Thirty-two students (9.2%) remarked that additional information would be beneficial. Fifty-one students (14.7%) utilized Inference to formulate alternatives. Most students who offered an alternative suggested putting the beetles into a zoo for protection. Other alternatives included placing the beetles into another habitat in the U.S., setting a monetary limit for protection, limiting pesticides and pollution in the beetle's habitat, and raising private money for protection. Only six students (2%) derived plausible conclusions. For example, "If humans did not pollute so much and destroy its habitat, so much money would not be needed to assist the beetle. Due to all that humans have done, the beetle

needs help.” Twenty-four students (6.9%) discussed possible consequences of decisions. “If the beetle is removed from the ecological system, the system will become fragmented and there may be ramifications that were unintentional.”

Few students utilized Interpretation, Analysis, Evaluation, or Self-regulation. No student summarized the author’s words in their own words. Only 21 students (6%) offered an example to help explain. One student compared the plight of the Salt Creek Tiger Beetle “like protection for the Bald Eagle brought back its population.” Only one student defined a term. “First of all, the Salt Creek Tiger Beetle is not a bug as the author commented. As its name states, it belongs to the beetle order, Coleoptera, of insects and not the true bug order, Hemiptera.” While no students analyzed the structure of the original argument, fifteen students used Analysis to compare and contrast. “While I do agree that this significant amount of land could be used more efficiently for the good of people, it’s also important to understand the need these beetles have for certain parts of the land.” Twelve students (3.4%) gave a reason for accepting their claim, though only four anticipated and responded to criticism. Although Self-regulation may be one of the more difficult critical thinking skills, given students’ acknowledged naiveté regarding this issue, it is surprising that only 17 students (4.9%) remarked on their own need for further inquiry. “I’ll admit that I don’t know that myself, and would have to know that info before calling the Tiger Beetle useless to humans.” Only five students (1.4%) reflected upon their own thinking while 13 identified their personal biases including; a farming background, living near the area affected, and their major (usually agronomy or entomology).

Post Semester Skills

From the pre to post semester, more students utilized Interpretation, Analysis, and Explanation. There was a decrease in use of Evaluation and Self-regulation. The largest increase in skill use was Explanation: giving reasons for accepting a claim. At the end of the semester, 52 students (17.2%) gave reasons for accepting their claim. For example, “If the ground can be farmed I think it should be. In the short-term we will have farmland to help the economy and help keep us moving out of debt. In the long run that ground will become less saline and produce more bushels of grain for the farmer, which will keep making more and more money.” Another example, “I feel that the money should be set aside to save the saline wetlands so the beetles live. The saline wetlands are the only habitat the Salt Creek Beetles can thrive in. If the wetlands are taken away so is the beetle. If no action is taken this insect will become extinct and thus, another species will disappear from Earth.” The second Explanation skill, anticipates and responds to criticism, saw a decline from four students pre-semester to no students post-semester.

Another positive increase in critical thinking use came from Inference- discussing possible consequences. At the end of the semester 43 students (14.2%) included possible consequences of decisions into their writing. Most of the possible consequences discussed were ecological. “Over time, the loss of wetlands is going to hurt the biodiversity of the community,” and “one facet of saving the Salt Creek Tiger Beetle that seems to be overlooked is the ecosystem as a whole. Ecosystems are dependent on their species that occupy the bottom rung of the food chain to sustain all of the upper-level organisms. Destroying the habitat of the Salt Creek Tiger Beetle will have ramifications beyond the short-term loss of one species.” Fewer students formulated alternatives in the

post semester assignment and there was virtually no change in deriving plausible conclusions.

In the post-semester assessment, more students (4.3% compared to 9.9%) utilized the Analysis skill of compare and contrast and were open to considering multiple viewpoints when making their argument. However, overall, the use of the skill remained low.

Table 7: Frequencies of use of Critical Thinking skills in writing assignment

Skill	Sub-skills	Pre percent (N = 346)	Post percent (N = 302)
Interpretation	summarizes	0.0%	5.3%
	example	6.1%	9.3%
Analysis	defines terms	0.0%	0.0%
	compares and contrasts	4.3%	9.9%
	analyzes structure of argument	0.0%	4.0%
Evaluation	assesses credibility	18.2%	5.3%
	additional information	9.2%	4.3%
Inference	derives plausible conclusions	1.7%	2.0%
	formulates alternatives	14.7%	7.6%
	possible consequences	6.9%	14.2%
Explanation	gives reasons	3.5%	17.2%
	anticipates/ responds to criticism	1.2%	0.0%
Self-regulation	recognizes need for inquiry	4.9%	0.3%
	reflects upon own thinking	1.4%	2.0%
	identifies personal biases	3.8%	4.3%

Discussion

Both the quantitative and qualitative data gathered for this study suggest room for improvement in students' critical thinking skills about environmental ethics. Although many students scored well on the quantitative assessment, others did not. And despite the ability to perform well on a quantitative assessment, qualitative results did not support that students have the ability to apply critical thinking skills.

Quantitative Results

These data highlight and reinforce the challenge of teaching critical thinking. Fifty-four percent of students showed no increase in critical thinking skills over the semester and only one question increased statistically. Qualitative results were also mixed. While there was an increase in use in 9 out of 15 skills, the overall use of individual skills was quite low (ranging from 0 to 18.2%) These results suggest that students can increase their critical thinking, but that a given curriculum or focus on critical thinking is not a guarantee for all students to gain in critical thinking or the magnitude or quality of the increase.

A students' disposition to think critically and their gender were positive predictors of both students' pre and post critical thinking, though not their change in critical thinking. Previous studies have also found a significant relationship between critical thinking skills and dispositions (Facione, Facione, & Giancarlo, 1996; Jones, Ratliff, Tibbetts, & Glick, 1994; Giancarlo & Facione, 1994). Facione describes the disposition toward critical thinking as the "consistent internal motivation to engage problems and make decisions by using critical thinking" (p. 5). Facione (1998) concluded "educational and professional success required nurturing one's consistent internal

motivation to think as well as developing one's thinking skills" (p. 16). The relationship found between gender and critical thinking supports results of others (Rudd et al., 2000), although others have found no relation (Friedel et al., 2008).

The time spent on the exam, expected grade, and previous experiences in an agriculture classroom were negatively related to students' pre and post critical thinking skills. The data suggesting that students who expected a higher grade in the class scored less well on the critical thinking exam could be due to student assumptions regarding the difficulty of the course and their ability to successfully complete the critical thinking assignment. This could also result if the ability to think critically is not related to the ability to successfully earn points in the class.

The negative relationship between students' previous courses in agriculture and lower critical thinking scores deserves specific attention. Given that the assessment is specifically about agriculture and environmental ethical issues, the low score could be due to a defense mechanism where students are afraid, or unable, to critically examine perspectives that seemingly threaten their way of life. Students with higher numbers of agriculture classes are likely from farms or rural areas and their high school offered agriculture based classes. As these students have an agricultural background, and their families may even derive their livelihood from farming, they are approaching the instrument with a different bias than other students. The emphasis in the high school agriculture curriculum may focus on the history of agriculture, agricultural economics and production and not on problem-solving or critical thinking. Students initially confronted with difference may react by being defensive and therefore lack the ability to consider multiple perspectives, especially those that challenge their status quo.

Many of the independent variables tested (Tables 4, 5, and 6) had no relation to pre, post, or change in students' critical thinking. This study did not find a link between GPA and critical thinking abilities. This may indicate that the ability to think critically is not needed to earn a high grade in a course. This finding supports the notion that college instructors rarely require critical thinking skills for successful completion of their class (Arum & Roska 2011; Whittington 1995).

Qualitative Results

Overall, use of critical thinking skills in the pre- and post- writing assignments was low. The maximum percentage of students who used any particular sub-skill was 18.2%. One positive note is the decrease in Formulates Alternatives compared to the increase in Discusses Possible Consequences. At the beginning of the semester, many students proposed that the beetles be moved to a zoo or into another habitat. The post-writing assignment saw very little of this thinking. Instead, a marked increase was seen in discussing possible consequences (from 6.9% to 14.2%) in regards to ecological ramifications and a greater understanding of biology and ecology. In the post assignment, more students were capable of applying concepts learned in class to the situation. Many more students were also able to give reasons to support their claims (3.5% to 17.2%). Early in the semester, many students either regurgitated the points of the original author or merely dismissed those points with little or no support. In the post assessment, more students took the time to offer their own reasons for their position. Given the team oriented, discussion based nature of the lecture and recitation sections, students received 16 weeks of practice explaining and defending their ideas to their classmates.

One interesting finding is how few students expressed the need for more information or to inquire further before making an informed decision. Many of the students, at least at the beginning of the semester, had never heard of the Salt Creek Tiger Beetle and yet only 32 students expressed a need for greater awareness and 17 discussed the need to personally understand the issue better. Post semester, only 13 students expressed the need for more information and one student discussed personally needing to investigate further. Although education is, in part, a process of gaining knowledge, it is also important for students to realize that there is much they do not know. Given that students' disposition to think critically had a positive relationship with quantitatively measured critical thinking skills, this finding is somewhat surprising. Overall, students' mean score on the critical thinking disposition Innovativeness was 26 (out of a highest 35). A high level of Innovativeness is described as,

“People who have a high Innovativeness disposition could be described as “hungry learners. They are consistently looking for new knowledge. Individuals who possess a high level of innovativeness want to know more about their profession, their situation, their life, and their world. A person with high Innovativeness is intellectually curious with new challenges and actively seeks to know more through research, reading, and questioning. This person is also characterized by his desire to know the truth, even if the truth conflicts with presently held beliefs and opinions” (Irani et al. 2007).

Given students' score on Innovativeness scale, one would expect a higher level of curiosity and willingness to admit that more information or inquiry on the student's behalf is necessary. This may indicate that although students report, and may truly believe, that they are intellectually curious, few exhibit the trait in actual academic endeavors.

Limitations

It has been shown that instructor's approach to critical thinking in the classroom has an effect on student learning (Balin et al., 1999; Halx & Reybold, 2005; Tsui, 2001). This study looked at students in a large introductory course that also met in smaller recitation sections. We did not analyze the impact of lectures compared to recitation on critical thinking. In addition, although the recitation instructors were trained in the curriculum that promoted critical thinking as well as definitions and concepts of critical thinking, we did not examine the effect of individual teachers on student critical thinking. How closely instructors followed curriculum guidelines and how well they demonstrated and promoted critical thinking was not examined. An experimental design that controlled for students exposure and experience with critical thinking in the classroom would allow researchers to better explain observed patterns.

Students completed the quantitative assessment outside of class time and were aware that the assignment was not graded. This could impact the effort students put forth on the assessment. The qualitative writing assignment, although completed in class, was also not graded other than for participation.

Admittedly, critical thinking is not the only skill that will be necessary to solve our environmental problems. Critical thinking requires that students hold their own and others values and beliefs in objective suspension before reaching a conclusion. This is a valuable skill. However, equally valid is the ability to have empathy for an individual or human or natural communities one is working with. Creativity will also be an invaluable skill when dealing with the complex and ever novel environmental problems we face in the 21st century.

Future Research

Future research should examine differences between increases in general critical thinking skills and increases in the ability to think critically specifically about environmental ethical issues. Another question is when during a students' course of study is it most beneficial to focus on critical thinking skills? The students in this study were predominately freshmen. Is it essential to start teaching critical thinking at the start of a college career or would it be more effective to wait until a sufficient amount of content knowledge is gained first? Should one precede the other or should they be taught in tandem? Given that implementing critical thinking activities and allowing time for students to practice said skills detracts from the amount of content knowledge imparted, is the focus on critical thinking for freshmen students benefiting them?

Future research should include longitudinal studies that span a students' time in college and into their careers. Answering this question could shed light on the question of when to include critical thinking into the curriculum. It is equally important to assess if students are retaining and utilizing critical thinking skills in their jobs. Furthermore, what impact does critical thinking have upon environmental outcomes? Research that examines variables that impact the results of environmental programs should include the level of critical thinking by both project leaders and managers as well as all stakeholders involved.

Research shows three areas that have an impact on student critical thinking 1) student abilities, behaviors, and characteristics 2) instructor abilities, behaviors, and characteristics and 3) curriculum (Quinn et al., 2009). This study did not examine the effects of differences in instructor abilities, behaviors, and characteristics. Future

research should look closely at different instructors teaching the same curriculum to the same students. This may only be possible at large universities teaching a class similar to that used in this study; with hundreds of students learning the same lecture curriculum but who have different recitation instructors.

Researchers should investigate the negative relation between agriculture classes and critical thinking abilities. Is this a local finding or will this be discovered repeatedly when looking at critical thinking in colleges of agriculture and natural resources? If this is a more general finding, what can be done to ensure that students are ready and capable of thinking critically about a subject, even if that subject seems threatening? In turn, how can instructors create a safe environment for discussion that ensures students feel comfortable exploring new ideas that create cognitive dissonance?

Implications for Practice

Previous findings, coupled with this study, demonstrate the importance of instructors in the process of increasing critical thinking skills of students. Instructors, whether faculty or graduate students, need more training in teaching critical thinking. If an instructor is unsure how to demonstrate critical thinking, questions to ask that require critical thinking, or assignments to give, then students will be less likely to improve their abilities. This may be a difficult task, given limited resources of time and money, but an important one given the lackluster abilities of students graduating from our institutions.

The relationship between students' previous courses in agriculture and lower critical thinking scores is an important finding for teaching agriculture and natural resources to freshmen students. Developmentally, when a person is first confronted with difference (be it race, culture, or *agri-culture*) they are often defensive. Although much

work regarding developmental models of cultural competency in regards to agriculture and agricultural education focuses on differences in race, culture, and gender (Bell, 2000; Guion, Brown, & Diehl, 2010; Guzman, Hill-Menson, & Greve 2007; Tiraieyari 2009), this research indicates that differences between the cultures that exist within agriculture (e.g. small scale family farms vs. agribusiness or organic vs. conventional practices) can precipitate feelings or ideas that impact critical thinking skills. This finding has important implications for teaching and, in turn, future agriculture and environmental professionals. The ability to consider alternative perspectives and engage in civil debate to ensure informed decisions is essential to deal with the diverse ethical perspectives and opinions on how to best deal with environmental issues. Although it is not a usual goal of instructors to increase the cultural competence of agricultural and environmental students, understanding where students are developmentally should influence curriculum and pedagogy. If students are confronted with alternative ideas before they are ready, or in a context or environment where they feel threatened or challenged, they may not retain information or be willing to engage in discussion or critical thinking.

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CHAPTER VI

Discussion

The above studies paint an interesting picture of critical thinking in regards to environmental ethics. It is clear that today's students will need to gain critical thinking skills while in college so that, as professionals, they can help solve some of the most pressing problems ever confronted by humanity. The environmental problems we are facing, and in turn their ethical implications, are global in scope and have no easy answers. Thus, our role as instructors becomes ever more crucial. More than imparting knowledge, we must help our students learn *how* to think, not just *what* to think. As the above studies indicate, it is not easy to understand, measure, teach, or evaluate critical thinking.

Despite the numerous definitions of critical thinking, all imply a rigorous cognitive process that allows people to engage in higher levels of analysis and apply their conclusions to problems. To foster thinking abilities that will serve students as well as society is one focus of higher education. The ethical problems we are facing require higher levels of critical thinking. The studies here examined the role of critical thinking in environmental ethics education, student abilities when entering college and whether or not instructors can measure and positively influence critical thinking abilities during a semester.

Previous research has examined critical thinking in the classroom. Chapter 1 was an attempt to coalesce that research into one model that shows the three ingredients to critical thinking development: 1) Student abilities, behaviors, and characteristics, 2)

instructor abilities, behaviors, and characteristics, and 3) curricula and activities. With the knowledge, I sought to investigate student abilities in a large introductory agriculture and natural resources course required for all students in the College of Agricultural Sciences and Natural Resources at the University of Nebraska- Lincoln. The research projects considered all three aspects of critical thinking in education.

It was necessary to address the difficulty of measuring critical thinking. Instructors are not likely to have the time to administer, or the money to utilize, one of the large commercially available general critical thinking assessment instruments. In addition, no measurement existed for critical thinking about environmental ethics. A 12-item multiple-choice assessment, The Environmental Ethics Critical Thinking Assessment, was created and validated with Item Response Theory. The instrument, the UF-EMI measurement of critical thinking disposition, and a writing assignment for qualitative analysis were administered to all students in the introductory course. First, freshmen students' results were separated for analysis. The purpose was to examine the abilities of students just entering higher education. Second, the results for all students in the course over three semesters were analyzed for pre and post semester abilities to look at change in critical thinking over the semester.

Overall, the results of students' use of critical thinking were disappointing, but not surprising. Anecdotally, many instructors will note that students have little desire to use, and rarely engage in, critical thinking. The research studies here confirm what many instructors already know. Arum and Roska (2011) recently wrote about the lack of critical thinking on college campuses. The results of the studies here support previous research. Although there were a few shining qualitative examples of critical thinking in

the writing assignment, and some students did improve their scores on the quantitative assessment, but in-large students showed little ability to think critically about environmental ethical issues.

I believe that these results are a product of many interacting variables that range from universal problems in higher educational systems to the individuals who currently inhabit our college classrooms. There are serious obstacles to the development of critical thinking in environmental, agricultural, and natural resource programs in higher education. Issues of funding and instructor allocation of time between research and teaching, student lack of interest or engagement in their studies, developmental barriers to seeing issues beyond black-and-white, and the stifling of debate on various agricultural and environmental issues all contribute to difficulties in teaching critical thinking.

However, at the same time I am hopeful. Although teaching critical thinking can be difficult, many instructors are, at the very least, seeking to understand and infuse their curriculum with activities that require critical thinking. Students may not enjoy the process of higher-level thinking required for these assignments, but they will be the better for them in the short and long term. Students may even find the focus on critical thinking more intellectually stimulating than lectures and memorization of content. It is also heartening to read students' assignments that demonstrates superior use of critical thinking skills. If instructors can demonstrate critical thinking and build upon the skills already in our students, the potential for higher levels of thinking is much greater.

Environmental leaders of the future will need many skills and abilities, one of which is critical thinking. The ability to look at problems from many different angles, to understand the interconnections between seemingly disparate events and issues, and to

effectively communicate to others are all critical thinking skills that will allow humanity to move forward in solving difficult environmental ethical problems. Instructors in higher education have an obligation to help students develop these necessary skills. The studies here are a start in investigating students' abilities in critical thinking regarding environmental ethics and instructor attempts to positively influence such skills. It is my hope that in the future all environmental professionals possess critical thinking skills that help them address critical ethical issues regarding the environment and that they learned and developed those skills during their time in college.

APPENDIX A
Environmental Ethics Critical Thinking Assessment

1. Which option below is an example of the argument in the passage?

"To many people, a species with a small population, a limited geographical range, is physically small or unattractive, has no immediate use to people, and has no relationship to any species of economic importance has no value."

- a. The polar bear, a magnificent and beautiful animal, was listed as an endangered species in 2008. Many people are concerned about the disappearance of this important species.
- b. In 1993, the Delphi sands flower-loving fly was officially listed as an endangered species. Only a few hundred acres of its original habitat remain. Many organizations were opposed to the listing of the fly as an endangered species.
- c. Overharvesting and habitat loss are causing some medicinal plants to become threatened or endangered including the popular American Ginseng.

2. What is the purpose of the question in the selection below?

"The illegal bushmeat trade contributes to species loss. In Western society, many see eating animals, such as primates and other wildlife, as wrong. However, locals in countries that eat bushmeat have long consumed such animals and often cannot afford other options. Who is right?"

- a. To indicate that Western society is correct to not want primates killed for meat
- b. To suggest that answers to complex problems are not always straightforward
- c. To suggest that local people have a right to eat primates for survival

3. Which sentence in the following paragraph is designed to trigger an emotional response in the reader?

"A cap-and-trade bill to reduce air pollution will limit our economic growth. 2) Our way of life is being threatened by eco-nazis who only care about the environment. 3) We should not listen to these people who don't care about everyday citizens."

- a. Sentence 1
- b. Sentence 2
- c. Sentence 3

4. Which option below provides an example which helps to explain the passage?
“In the future, we will realize that eating animals is unethical. It is difficult to see a prejudice that the majority of society currently holds. Through time, we have expanded our ethical consideration to include those previously thought to be unworthy of ethical concern. So will be the case with animals.”

- a. Although today it is unthinkable, at one time, slavery was not seen as unethical.
- b. In the past, people cared more about the environment than we do today.
- c. It is important to be a vegetarian because meat production requires too much water.

5. What is the purpose of the paragraph below?
“The financial costs of addressing climate change are enormous. These costs include investing in alternative technologies and sharing resources with other countries. There are also potential negative outcomes from a large financial investment such as less money to invest in other issues such as education and defense. But, what are the costs of inaction on climate change?”

- a. To suggest that there may be costs to not addressing climate change.
- b. To imply that the financial costs of solving climate change are too great.
- c. To suggest that we don't have enough information to make a decision about the costs of climate change.

6. Which option below provides an example which helps to explain the passage?
“An action is ethical only if one would be willing for that action to become a universal law. Therefore, if we believe that businesses regulation is necessary to reduce pollution, then we must also regulate personal, household, and individual waste.”

- a. Recycling bins should be placed throughout towns and cities for people who want to recycle.
- b. Small businesses should not have to reduce their waste or pollution because it would be too cost prohibitive.
- c. By law, all businesses, households and individuals should have to sort, recycle, and compost their waste.

7. Suburban lawns are often sprayed with chemicals to keep away weeds. Is the passage below intended as a reason for or against limiting the number of weeds in lawns?

“As I’ve told my neighbors, I feel bad about lowering the value of their property. I mean, it isn’t my goal to have a front yard that, by standard reckoning, is unattractive. The unkept look of my lawn is just a byproduct of a conclusion I reached a few years ago: the war on weeds, though not unwinnable, isn’t winnable at a morally acceptable cost.” -

Wright, R. April 20, 2010 NY Times, The Dandelion King

- a. This passage was intended as a reason for limiting the number of weeds in lawns.
- b. This passage was intended as a reason against limiting the number of weeds in lawns.

8. Which sentence in the following paragraph is designed to trigger an emotional response in the reader?

“1) When agribusiness companies use seed protection technology to ensure that farmers have to buy seeds from the company every year, the company is trying to ensure an adequate financial return for their investment. 2) When farmers save seed, the company’s profit is reduced. 3) The farmers become thieves that are willing to steal from a company.”

- a. Sentence 1
- b. Sentence 2
- c. Sentence 3

9. In the passage below, identify the sentence that is the main point of the paragraph.

“ 1) Non-human animals lack self-awareness. 2) It should stand to reason that one can only extend ethical consideration to a being that also has the capacity to reciprocate ethical consideration. 3) Therefore, humans do not have an ethical responsibility towards other non-human beings.”

- a. Sentence 1
- b. Sentence 2
- c. Sentence 3

10. In the passage below identify the sentence that is the main point of the paragraph.

“1) The Great Pacific Garbage Patch is a floating gyre of garbage in the Pacific Ocean that is estimated to range from the size of Texas to larger than the United States.

2) Marine animals, including birds, turtles, and fish, are affected by the plastics and

toxins in the garbage. 3) The waste produced by humans and dumped into the ocean is an ecological tragedy that must be fixed.”

- a. Sentence 1
- b. Sentence 2
- c. Sentence 3

11. Is the passage below intended as a reason for or against regulating greenhouse gases?

“For one thing, as visible pollution has diminished, so has public concern over environmental issues. According to a recent Gallup survey, “Americans are now less worried about a series of environmental problems than at any time in the past 20 years. This decline in concern would be fine if visible pollution were all that mattered — but it isn’t, of course. In particular, greenhouse gases pose a greater threat than smog or burning rivers ever did. But it’s hard to get the public focused on a form of pollution that’s invisible, and whose effects unfold over decades rather than days.” - Krugman, P. May 2, 2010. NY Times. Drilling, Disaster, Denial

- a. This passage was intended as a reason for regulating greenhouse gases.
- b. This passage was intended as a reason against regulating greenhouse gases.

12. What is the author’s purpose in asking the questions in the selection below?

“Is field work necessarily improved by being replaced by a machine? Does a worker invariably work better, more ably, with more interest and satisfaction, when his power is mechanically magnified? And is a worker better off working at a “pedestrian” farm task or unemployed in an urban ghetto? In which instance is his country better off?” –

Wendell Berry, *Agricultural Solutions for Agricultural Problems* 1978

- a. To imply that countries that rely on manual farm labor are superior to countries who do not.
- b. To imply that mechanization of agriculture has improved our quality of life.
- c. To imply that there is value in manual farm labor.

Correct Answers

1. B
2. B
3. B
4. A
5. A
6. C
7. B
8. C
9. C
10. C
11. A
12. C

APPENDIX B
Institutional Review Board Letters of Approval



June 28, 2010

Courtney Quinn
School of Natural Resources

Gina Matkin Agricultural Leadership, Education and Communication
300 AGH, UNL, 68583-0709

IRB Number: 20100610988
EX Project ID: 10988
Project Title: Improving Critical Thinking about Environmental Ethics

Dear Courtney:

This letter is to officially notify you of the approval of your project by the Institutional Review Board (IRB) for the Protection of Human Subjects. It is the Board's opinion that you have provided adequate safeguards for the rights and welfare of the participants in this study based on the information provided. Your proposal is in compliance with this institution's Federal Wide Assurance 00002258 and the DHHS Regulations for the Protection of Human Subjects (45 CFR 46) and has been classified as Exempt Category 2.

You are authorized to implement this study as of the Date of Final Approval: 06/28/2010. This approval is Valid Until: 12/31/2012. 1. Please include the IRB approval number (IRB#20100610988 EX) on the on-line informed consent document. Please email a copy of the document, with the IRB number included, for our records.

If you need to make changes to the message please submit the revised message to the IRB for review and approval prior to using it. We wish to remind you that the principal investigator is responsible for reporting to this Board any of the following events within 48 hours of the event: Any serious event (including on-site and off-site adverse events, injuries, side effects, deaths, or other problems) which in the opinion of the local investigator was unanticipated, involved risk to subjects or others, and was possibly related to the research procedures;

Any serious accidental or unintentional change to the IRB-approved protocol that involves risk or has the potential to recur. Any publication in the literature, safety monitoring report, interim result or other finding that indicates an unexpected change to the risk/benefit ratio of the research;
Any breach in confidentiality or compromise in data privacy related to the subject or others; or Any complaint of a subject that indicates an unanticipated risk or that cannot be resolved by the research staff.

This project should be conducted in full accordance with all applicable sections of the IRB Guidelines and you should notify the IRB immediately of any proposed changes that may affect the exempt status of your research project. You should report any unanticipated problems involving risks to the participants or others to the Board. If you have any questions, please contact the IRB office at 472-6965. Sincerely,

A handwritten signature in black ink that reads "Becky R. Freeman".

Becky R. Freeman, CIP for the IRB



June 11, 2010

Courtney Quinn
Agricultural Leadership, Education and Communication

Gina Matkin Agricultural Leadership, Education and Communication
300 AGH, UNL, 68583-0709

IRB Number: 20100610922 EX Project ID: 10922
Project Title: Development and Validation of a Critical Thinking Assessment for Environmental Ethics

Dear Courtney:

This letter is to officially notify you of the approval of your project by the Institutional Review Board (IRB) for the Protection of Human Subjects. It is the Board's opinion that you have provided adequate safeguards for the rights and welfare of the participants in this study based on the information provided. Your proposal is in compliance with this institution's Federal Wide Assurance 00002258 and the DHHS Regulations for the Protection of Human Subjects (45 CFR 46) and has been classified as Exempt Category 2.

You are authorized to implement this study as of the Date of Final Approval: 06/11/2010. This approval is Valid Until: 12/30/2011. 1. The approved informed consent form has been uploaded to NUgrant (Informed Consent Form-Approved.doc file). Please use this form to distribute to participants. If you need to make changes to the informed consent form, please submit the revised form to the IRB for review and approval prior to using it.

We wish to remind you that the principal investigator is responsible for reporting to this Board any of the following events within 48 hours of the event: Any serious event (including on-site and off-site adverse events, injuries, side effects, deaths, or other problems) which in the opinion of the local investigator was unanticipated, involved risk to subjects or others, and was possibly related to the research procedures; Any serious accidental or unintentional change to the IRB-approved protocol that involves risk or has the potential to recur; Any publication in the literature, safety monitoring report, interim result or other finding that indicates an unexpected change to the risk/benefit ratio of the research; Any breach in confidentiality or compromise in data privacy related to the subject or others; or

Any complaint of a subject that indicates an unanticipated risk or that cannot be resolved by the research staff. This project should be conducted in full accordance with all applicable sections of the IRB Guidelines and you should notify the IRB immediately of any proposed changes that may affect the exempt status of your research project. You should report any unanticipated problems involving risks to the participants or others to the Board. If you have any questions, please contact the IRB office at 472-6965.

A handwritten signature in black ink that reads "Becky R. Freeman".

Sincerely,

Becky R. Freeman, CIP for the IRB

Appendix C

Cover Letter to Study Participants

Development and Validation of a Critical Thinking Assessment for Environmental Ethics

June 2010

Dear «First_Name» «Last_Name»:

Future professionals in agricultural, natural resource, and environmental professions will have to make difficult decisions that have ethical consequences for human and natural communities. Students need to learn the critical thinking skills that will help them evaluate ethical claims and consequences of economic, social, and environmental policies and actions. To know that we are teaching students necessary skills, it is imperative to evaluate their critical thinking skills about environmental ethics. For my dissertation research, I am developing and validating a critical thinking assessment for environmental ethics.

I would like to utilize your expertise for this research. You were selected for this project because of your work with critical thinking, environmental ethics, and/or natural resource and agricultural issues. I am asking your expertise to help with face and content validity. The process will take about one hour to complete. All findings used in any written reports or publications which result from this evaluation project will be reported in aggregate form with no identifying information. I will be contacting up to three participants in this process for an interview to further understand your reasoning and comments on questions. The interview process, should you participate, will take up to one hour. Your name will be attached to your responses to allow me to contact you regarding your answers so that I can ensure the best possible assessment tool. However, your identities will not be associated with published results and will remain confidential in all reports, papers, and dissertation materials.

There are no known risks to participants. If you have any questions about this study or if you want to voice any concerns, please feel free to contact, Courtney Quinn, Graduate Research Assistant at (402) 480-2088 or courtney_quinn@yahoo.com or Dr. Gina Matkin (402) 472-4454 at (402) 472-8210 or gmatkin@unl.edu. Please contact the University of Nebraska-Lincoln Institutional Review Board at (402) 472-6965 for the following reasons: you wish to talk to someone other than the research staff to obtain answers to questions about your rights as a research participant; to voice concerns or complaints about the research; to provide input concerning the research process; or in the event the study staff could not be reached.

You are free to decide not to participate in this study. You can also withdraw at any time without harming your relationship with the researchers or the University of Nebraska-Lincoln.

You are voluntarily making a decision whether or not to participate in this research study. Your signature certifies that you have decided to participate having read and understood the information presented. You will be given a copy of this informed consent to keep.

Measuring Critical Thinking for Environmental Ethics
August 2010

Dear Student:

Future professionals in agricultural, natural resource, and environmental professions will have to make difficult decisions that have ethical consequences for human and natural communities. As a student, you need to learn the critical thinking skills that will help you evaluate ethical claims and consequences of economic, social, and environmental policies and actions. To know that we are teaching students necessary skills, it is imperative to evaluate critical thinking skills about environmental ethics.

To study how teaching affects students' critical thinking about environmental ethics, we are inviting you to participate in an assessment. You will take the assessment 2 times, at the beginning and again at the end of the semester. The assessment will take approximately one hour each time. The assessments will be completed online and therefore you may complete it on your own time at a computer of your choice. You will also have the opportunity to participate in interviews. If you choose to participate in the interviews, each will take approximately thirty minutes. Interviews will be conducted on campus at a time and location convenient for all interested participants.

There are no anticipated risks to participants. All findings used in any written reports or publications from this project will be reported in aggregate form with no identifying information.

You are free to decide not to participate in this study. Your instructors will not know if you choose to participate or not. Your grade will not be affected by the outcome of this study. You can also withdraw at any time without harming your relationship with the researchers, your instructors, or the University of Nebraska-Lincoln.

If you have any questions about this study or if you want to voice any concerns, please feel free to contact, Courtney Quinn, Graduate Research Assistant at (402) 480-2088 or courtney_quinn@yahoo.com or Dr. Gina Matkin (402) 472-4454 at (402) 472-8210 or gmatkin@unl.edu. Please contact the University of Nebraska-Lincoln Institutional Review Board at (402) 472-6965 for the following reasons: you wish to talk to someone other than the research staff to obtain answers to questions about your rights as a research participant; to voice concerns or complaints about the research; to provide input concerning the research process; or in the event the study staff could not be reached.

You are voluntarily making a decision whether or not to participate in this research study. Clicking 'accept' below certifies that you have decided to participate having read and understood the information presented.

Appendix D

Letter of Approval to Reprint Chapter II from *Journal of Natural Resources and Life Science Education*

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Sincerely,

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