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Teaching and Evaluating Critical Thinking in an Environmental Context

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As environmental education strives to create an informed citizenry capable of addressing complex problems, critical thinking is an integral part of this effort. This research guides environmental educators in defining, teaching, and evaluating critical thinking by summarizing a pilot study with an undergraduate forest issues course designed to increase critical thinking skills in students and move them toward responsible environmental citizenship. The course taught critical thinking skills explicitly, correlating each discussion and assignment to the specific critical thinking skills addressed. An essay-based assessment of critical thinking skill, a Likert-scale assessment of critical thinking disposition and qualitative interviews measured critical thinking in students. After the 15-week course, students significantly improved in critical thinking skills ($n = 16$, $p < .05$) and skills were correlated with critical thinking dispositions ($n = 13$, $p < .05$). Phenomenological analysis of interviews revealed that students engaged in critical thinking in a variety of situations, some with citizenship implications, and struggled with the role of emotion in critical thinking. These experiences informed recommendations for instruction and evaluation strategies.

CRITICAL THINKING: AN INTEGRAL PART OF ENVIRONMENTAL EDUCATION

Environment-based education programs strive to create a citizenry that can use information to solve problems and make environmentally

responsible decisions. Increasingly, these programs must correlate with standardized objectives and demonstrate their effectiveness through evaluation. Critical thinking skills are common desired outcomes and can bridge environmental education with state and national standards; when taught explicitly in the context of environmental issues, these skills can become integrated into student behavior and help to create the environmental citizenry that environmental educators envision (Ernst & Monroe, 2004). Educators are challenged to define what critical thinking is, decide how to teach it and devise ways to measure it in their students. This article describes this process in the

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context of an undergraduate course in forest issues.

Teaching to improve thinking is a concept that is rooted in Greek philosophy, was championed by Dewey in the post–World War I United States, was modified by Bloom in the 1950s, and regained momentum in the 1980s. In 1977 the Tbilisi Declaration stated the importance of preparing students to wrestle with complex social and environmental issues by teaching critical thinking skills (Intergovernmental Conference on Environmental Education, 1978). Critical thinking comprises a series of skills and dispositions that can help citizens make sense of their world and participate in a democratic dialogue.

Although there are several definitions of critical thinking, the common purpose uniting them is the need to prepare citizens to understand and evaluate complex arguments about current issues. Robert Ennis was one of the first researchers to define critical thinking as “reasonable, reflective thinking that is focused on deciding what to believe or do” (Ennis, 1987, 10). Although this definition focused on the end product, Richard Paul and Linda Elder’s definition focused on perfecting the quality of the process (Elder & Paul, 2001). In 1990, a group of 30 experts convened in a Delphi study and determined that critical thinking is a process divided into skills and dispositions (American Psychological Association, 1990). This is the most common definition of critical thinking to date, and was used in the creation and assessment of the undergraduate course. The six skills defined by the Delphi study include:

- Interpretation: The ability to understand information.
- Analysis: The ability to identify the main arguments presented.
- Evaluation: The ability to judge whether this argument is credible and valid based on the logic and evidence given.
- Inference: The ability to decide what to believe or do based on solid logic, and to understand the consequences of this decision.
- Explanation: The ability to communicate the process of reasoning to others.

- Self-Regulation: The ability to monitor one’s own thinking and correct flaws in logic.

Seven dispositional elements were also identified by this panel of experts, and include (Facione, 1998):

- Inquisitiveness: Concern to become and remained well-informed.
- Truth-seeking: Willingness to face one’s own biases and reconsider views.
- Critical thinking self-confidence: Trust in one’s ability to reason.
- Open-mindedness: Flexibility in considering alternative viewpoints.
- Systematicity: Systematic thinking that follows a linear process.
- Analyticity: The willingness to pick apart your own and others’ logic.
- Cognitive Maturity: Being persistent in seeking the truth.

The Delphi study identified measurable skills and dispositions, which aided in designing assessment instruments. However, the Delphi study explicitly excludes the role of ethics, or “right vs. wrong” decision making. Martin (1992) and Fox (2002) are among those who criticize this characterization and urge for a moral element to be added to critical thinking. In addition, the Delphi study does not explicitly address the quality of the explanation skill. Therefore, this research used Paul and Elder’s intellectual standards to assess the quality of the explanation of logic used, namely clarity, accuracy, precision, relevance, breadth, and depth (Elder & Paul, 2001).

FORESTS FOR THE FUTURE—CRITICAL THINKING IN CONTEXT

This research examined the effectiveness of critical thinking teaching techniques used in an interdisciplinary undergraduate forest issues course at the University of Florida.

Involving six faculty, the course was developed to teach each of the critical thinking skills explicitly in six different modules that each addressed a current social issue in forest management. For each module, a specific critical thinking skill was highlighted and modeled. Topics included clearcutting, global warming, genetically modified organisms, and tropical forest management. During each module, faculty introduced themselves and their biases, presented information from multiple sources and analyzed its credibility, and asked students to describe their own critical thinking process on the module topic. Facione and others agree that the instructor is a crucial determinant of the success of a critical thinking course (McMillan, 1987). Faculty of the course were instructed in critical thinking teaching and modeling techniques by the researcher prior to the start of the semester. Recommendations for teaching techniques were adapted from Facione (1998) and included:

- Teaching students what each skill is, and when and how to use it.
- Modeling appropriate and logical reasoning.
- Justifying why critical thinking is important.
- Allowing students to practice, with evaluation as a crucial component.

At the beginning of the course, students were given a grading rubric describing each critical thinking skill and what demonstration of that skill should include—this rubric was used for grading each written assignment in the course (Table 1). Wade (1995) found that writing promotes greater self-reflection and depth of logic compared to oral communication in a university setting, which provided the justification for the course's writing-intensive curriculum. Assignments included critiquing the critical thinking (or lack thereof) demonstrated by authors in articles and video segments, presenting multiple sides of an issue in an oral presentation, and peer critiques of students' papers.

Table 1
Critical thinking skill rubric

Interpretation	Total Score: (___ out of 20) The writer correctly identifies the main purpose. ___ The writer articulates divergent points of view. ___ The writer attempts to categorize information. ___ The writer summarizes main ideas or paraphrases in their own words. ___
Analysis	Total Score (___ out of 20) The writer identifies relationships among statements, concepts, judgements, and opinions. ___ The writer detects arguments supporting and contesting points of view. ___ The writer distinguishes relevant from irrelevant points of view. ___ The writer identifies biases and unstated assumptions. ___
Evaluation	Total Score: (___ out of 20) The writer reassesses credibility of evidence. ___ The writer assesses credibility of points of view and opinions. ___ The writer raises questions or objections to discover weaknesses in an argument. ___ The writer offers supplementary information that may strengthen or weaken an argument. ___
Inference	Total Score: (___ out of 20) The writer derives plausible conclusions from the given information ___ The writer makes logical recommendations (not questions) for action ___ The writer gives recommendations (not questions) for further inquiry. ___ The writer identifies potential consequences. ___
Explanation	Total Score: (___ out of 20) The writer demonstrates breadth and depth of information. ___ The writer communicates clearly, accurately and precisely. ___ The writer uses relevant information to support their opinion. ___ The writer logically communicates their lines of thinking. ___
Self-Regulation	Total Score: (___ out of 20) The writer demonstrates self-questioning and self-validation ___ The writer recognizes their own need for further inquiry. ___ The writer reflects upon and justifies own thinking process. ___ The writer identifies personal biases. ___

EVALUATING CRITICAL THINKING: A UNIQUE APPROACH

Higher education's emphasis on teaching critical thinking skills has led to both qualitative and quantitative approaches in measuring critical thinking. The quantitative approach uses hypothetical situations with multiple-choice or Likert scale instruments to determine students' ability to think critically (NPEC, 2001; Clifford et al., 2004; Lampert, 2006). Undergraduate students' experiences and perceptions of critical thinking skills have also been studied from a qualitative perspective using interviews (Phillips & Bond, 2004).

Both quantitative and qualitative techniques were used in this study. Ennis (1993) and others advocate the use of essay assessments, scored with a rubric, to assess critical thinking in smaller samples. Although scoring these rubrics can be a challenge to instrument reliability, the essay approach was useful in probing the extent to which students utilized all six skills, and provided a real-world scenario by which to test students' skill development.

The essay-based skill instrument was created for this course, and asked students to critically analyze a magazine article and reflect on the thinking process they had used. The same article was used in both pre- and posttests. As shown in Table 1, each skill was divided into 4 sub-skills as identified by the Delphi study and assigned a number from 1 to 5, depending on the quality of the response. A rubric was devised to identify evidence of each of the skills in student essays, and scored using this rubric. Due to resource constraints, only one researcher scored both pre- and posttests, but subjectivity was minimized by assigning random numbers to student responses. Sample responses and scores are given in Table 2.

Students' scores ($n = 16$) were compared using a Student *t*-test for paired samples. Posttest scores for all students were higher than pretest skills. Significant gains in self-

regulation, analysis, evaluation, and total critical thinking skills were observed ($p < .05$). These three skills may be "new" to students; as they expressed in evaluations and interviews, this course was the first they had taken that asked them to address their own biases and evaluate the logic of the assigned readings. Self-regulation, analysis, and evaluation may also be the skills that produce more distinct, easily recognizable written evidence than the other skills. No significant relationship was found between skill gain and students' prior experience in critical thinking courses, which may indicate that while the skills were familiar, the teaching methods employed in this course contributed to students' increased competency in critical thinking skills.

The University of Florida's Engagement, Cognitive Maturity and Innovation (EMI) assessment measured students' critical thinking dispositions before and after the course. Pretest and posttest mean scores were compared using a Student's *t*-test for paired samples. Students did not significantly gain in critical thinking disposition over the course, and this result is not surprising. Dispositions were not a focus of the course, and while a correlation between skill and disposition was 0.61 ($n = 13$, $p < .05$), it is assumed that changes in personality and behavior happen gradually and may not be detected in a semester.

Although quantitative data are useful to score and measure significance of posttest change in skills and dispositions, there are additional aspects of critical thinking that are better explored using the assumptions and methods of qualitative analysis. Moving beyond quantifying students' skills are questions of utility and perceptions: When, and in what contexts, do students use the critical thinking skills they have? What is the process they engage in to think critically? What are students' perceptions and opinions about critical thinking in general—is it a useful skill set? These questions were asked during student interviews and analyzed using the qualitative perspective of phenomenology to add an integral dimension to the understanding of critical thinking.

Table 2
Examples of scoring student essay exams

Interpretation 14 out of 20	"The purpose of this article is to activate people against the logging practices used on the Cumberland Plateau. The author and his constituents are of the opinion that clearcutting and Loblolly planting over the forest on the plateau are 'crimes against the planet.' Bary Graden, on the other hand, is the operations manager for Bowater. He sees the practices being used to harvest paper from the plateau as environmentally responsible, and employs an environmental auditor who supposedly makes sure this is true."
4 out of 20	"The article is very informative and useful piece of information. It portrays a reality that few of us comprehend or at least don't like to think about. Articles such as these expose this country for what it truly is; a country just like any other; this great nation filled with greedy individuals that unlike other better known tyrants mask their transgressions with supposed laws and regulations, all efficiently bent to accommodate their financial interests."
Self regulation 12 out of 20	"I'm not a bad person. If there is a massacre of helpless trees and extinguishing of endangered animals, I'm going to sympathize with them. The problem is that I'm not sure I can believe anything that the author is trying to tell me. His biases work against him. I acknowledge the need for materials coming from the forest, but at the same time, I'm deeply rooted in naturalistic and aesthetic values. They don't usually clash—there is a clear balance in my head. Even looking back on the beginning of the year and how easily I was persuaded to be anti-corporation by this article is enough to make me feel ashamed. That being said, I can kind of see where he's coming from. I visited a friend who lives in the Cumberland Plateau over Spring Break and ... seeing the destruction made me sad for a second, and then I stopped to consider the other side of things. In the end, I was not swayed by Schoumatoff's article. It only fueled a desire to see the industry's point of view."
7 out of 20	"Being relatively sheltered for the majority of my younger years, I was never truly privy to the desolation and the grave issues circling about the forests. At the time, all I could gather was that cutting down the forest was bad. I stand by my ideology of eventually restricting deforestation as much as possible. The strength of my opinions has drastically increased due to the strong catharsis of the article. The potency would never have been quite as strong as they are had I passed on reading the article, and it came second only to seeing the devastation first-hand."

Descriptive at its core, phenomenology seeks to move beyond conventional perceptions of lived experiences to unearth the structures that underlie them (Bentz & Shapiro, 1998). To understand students' experiences and perceptions of critical thinking, in-depth interviews were conducted, transcribed, and analyzed using the phenomenological method as identified by Moustakas (1994). Subjects were selected purposively based on high pretest scores from a critical thinking skills instrument. Six students qualified for the study, four volunteered to interview and three completed the interview process. The process of engaging in phenomenology requires an intense and deep exploration of critical thinking from each student's perspective, and a proper consideration of these demand more space than is possible here; the complete analyses can be found in Hofreiter (2005).

What follows here is a generalized statement of the similarities in three students' experiences of critical thinking; this is known as the essence statement.

For these students, the experience of critical thinking began in childhood with the realization that multiple viewpoints and cultures exist. These experiences were nurtured by relatives and friends who demonstrated an acceptance of these multiplicities and cultivated an introspective, inquisitive nature in the child. Early school experiences dampened these natural instincts, focused on content memorization and placed an emphasis on repeating a correct answer. The students responded to this by searching for other viewpoints to counter this instruction, and/or fell into an acceptance of this technique in order to perform well. Instruction shifted in later grades, when the students

were encouraged to express their own opinion. This transition initially incited emotions of fear in making a mistake, and confusion as to what was expected, but eventually translated into feelings of empowerment and self-confidence.

As these students described, the process of critical thinking began with a problem or issue. Students looked within, kept an open mind, and judged their own emotional reaction to the issue. Once their own bias was identified, the new information was considered and judged for its credibility; this involved comparing it to other previously accepted information, considering the information's source and consulting others. The students, alone or in a group, arrived at a judgment of what to do or think based on the analysis of the information and its implications for others.

The role of emotion complicated critical thinking for these students—they either defaulted on using any critical thinking in favor of emotion (i.e., did not want to hurt the feelings of friends by engaging in critical thinking), used emotion to gauge the proximity of the subject to their moral center (and did not think critically about those issues they felt very close to), or attempted to suppress emotion entirely because it got in the way of the logical process. Thus, these students used critical thinking to make strategic decisions and form opinions about issues, but it was used more frequently with topics they felt less strongly about. After engaging in critical thinking, an action or change in opinion occurred, or the conclusion of the thinking (e.g., clearcutting is not as detrimental as previously thought) was stored for later consideration. Overall, students saw critical thinking as a useful skill set, citing success in the workplace, the ability to achieve desired outcomes, and helping their role as citizens in the global community as benefits to thinking critically.

While students gained in critical thinking throughout the semester and showed significant gains in the self-regulation, analysis, and evaluation skills, interviews of the highest performers indicated the complexities of using critical thinking in context. Highly emotional issues tended to bypass critical thinking channels

in these students, and the moral implication of their conclusion also factored into students' decisions of what to do or believe about an issue. The role of emotion, as well as incorporating morality into decision making, is not explicitly addressed in the Delphi study. As Dewey (1956) and others caution, it is crucial to give students tools for addressing emotion in their thought processes. Although some techniques were used, and included here, to address emotion in critical thinking, the need for more research into effective techniques is needed; this is especially relevant in deciding how to teach the inference skill. Facione (1995) described a similar opportunity when he suggested that courses endeavor to teach critical thinking skills should venture into uncharted territory and attempt to address dispositions during the semester; this course did not, and subsequently saw no change in students' critical thinking dispositions.

TEACHING FOR CRITICAL THINKING: SUGGESTIONS FROM THE CLASSROOM

Tip 1: Teach Critical Thinking Explicitly

Prior research indicated the need to teach critical thinking skills directly and allow students to practice these skills with opportunities for feedback (Beyer, 1987). Course evaluations and student interviews confirmed that students preferred to be given explicit instructions on how to think critically. Students were given the rubric in Table 1 at the beginning of the term; their responses were graded using this same rubric. In the course, each module followed a similar format:

1. Students reflected on their own incoming biases.
2. Professors introduced information from multiple perspectives on the issue.

3. Students and professors engaged in a question and answer session.
4. Students wrote and presented on the effect of the lesson on their thinking.
5. Professors modeled the critical thinking process they used to come to their own conclusion about the issue.

Significant gains in analysis, evaluation, and self-regulation are assumed to be related to this instructional model. Steps 1 and 4 teach the self-regulation skill, step 2 models analysis, and step 3 forms the basis for evaluation. Time devoted to teaching these skills and allowing students to practice them was an essential component of the course. Educators can use Table 1 as a formative tool to design their education program around teaching specific critical thinking skills.

Tip 2: Critical Thinking Skills Should be Modeled by Instructors

Fox (2002) cautions against consciously or subconsciously teaching with a “right” answer in mind. Freire (1993) advises instructors to be open to changing their viewpoints based on student responses. As described in student interviews and evidenced by a significant improvement in the analysis skill, instructors modeling critical thinking and admitting their biases helped students learn these skills. Instructors talked through their own thinking processes about an issue, including criticizing articles, commenting on bias and faulty logic during video segments, and presenting the history of their own opinion to students.

Tip 3: Use Real-World Examples to Teach Critical Thinking Skills in Context

During the 1980s, a discussion emerged between those who supported discipline-specific and non-specific instruction in the newly identified critical thinking skills (Ennis, 1987; McPeck, 1990). A synthesis of the early ar-

guments concluded that critical thinking programs need to be taught within specific disciplines, and that general thinking skills were apt to grow out of this instruction. As environmental educators, teaching in context is an integral component of most programs. An additional benefit to incorporating critical thinking into these programs is the opportunity for students to wrestle with current issues and decide what they should do, or believe, using the logical tools they have learned. For example, the assignment to help students understand the analysis skill was to write a speech as the burn boss of a preserve, addressing homeowners’ concerns about a planned prescribed burn near their neighborhood. Students used the analysis skill to synthesize the most logical arguments for and against prescribed fire and address both sides of the issue in their speeches.

Tip 4: Begin with Students’ Core Values, then Move to Information and Logic

The teaching techniques used in this course were shown to be effective for improving self-regulation. For many students, this was the first course that asked them explicitly what their initial opinions were about the issue, and to outline how those opinions changed throughout the module. Although students significantly increased their skill in self-regulation, inference skills improved but did not increase significantly. As discussed, emotion and morality were a challenge to thinking critically, especially with issues that impacted students’ loved ones or friends, or with issues that directly informed their identity. More time given to discussing the role of emotion, which often serves as a catalyst for engaging in critical thinking (Martin, 1992), and the moral parameters students already use in decision making, may improve the inference skill. Suggested questions to incorporate the six critical thinking skills in a discussion, beginning with Self-Regulation, are:

- Self-regulation: What are your initial emotional reactions to and opinions about this

issue? Where do you think those reactions come from? What are your core values that are challenged by this issue?

- Interpretation: What do you know about this topic? What do you know you don't know?
- Analysis: What are the arguments /controversies surrounding this issue?
- Evaluation: Now that you've had this experience, which point of view makes more sense, and why?
- Inference: What could we do about this issue? What would be the effects of that decision, and how do we choose what to do based on those effects?
- Explanation: How can we effectively communicate our thinking process and any conclusions reached?

CONCLUSION

The critical thinking evaluation and teaching techniques used in this forest issues course were useful in teaching undergraduate students to think critically about environmental issues. These techniques improved students' ability to demonstrate and use critical thinking skills and can be useful models for educators. However, it is clear in the analysis that critical thinking is also affected by emotion and morality, which are not addressed in traditional critical thinking techniques. These have the potential to either guide, or disrupt, the critical thinking process—the teaching techniques suggested here begin to address these factors, but additional research is needed to determine effective techniques for addressing the role of morality and emotion in thinking critically. Teaching critical thinking skills explicitly and in real-world contexts, modeling these techniques and evaluating them with both qualitative and quantitative assessment methods are all potentially successful strategies for creating a more informed citizenry able to address the world's complex problems.

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