ENHANCING STUDENTS' CRITICAL THINKING SKILLS THROUGHOUT THE CURRICULUM THROUGH THE USE OF "APPLIED CRITICAL THINKING"

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ABSTRACT

Using elements of Bloom's Taxonomy, Critical Thinking, and Scientific Research theory, Embry-Riddle Extended Campus adult learners can be taught how to become more effective critical thinkers by studying the elements of critical thinking necessary to succeed in each course they take. As the specific situational demands for academic success in each course dictate, these adult learners learn to first succeed in identifying the critical thinking elements in each course, then in the overall academic discipline of each course, and, eventually, in each professional and personal life situation they become involved in. Relying on the critical thinking skills necessary to succeed in information retrieval using online technology and finding solutions to problems through database searching and WWW search engines, adult learners can effectively become critical thinkers and information finders. It was concluded that Bloom's Taxonomy is an appropriate educational critical thinking guideline, and that extended campuses should create and support "critical thinking across the curriculum" programs. It was recommended that critical thinking across the curriculum and information retrieval skills be adopted by ERAU's Extended Campus as syllabus learning outcomes for all courses.

Chapter I
INTRODUCTION

According to many leading educational authorities, promoting and fostering critical thinking skills is an important goal of higher education (McBride & Reed, 1998). Facione et al. (1998) mention that people who possess critical thinking skills are likely to provide reasoned consideration to context, evidence, theories, procedures and criteria in order to form a purposeful judgment.

In 1984, the National Institute of Education recommended that university-level curricula provide for "the development of capacities of analysis, problem solving, communication, and synthesis" (p.43). Likewise, the Association of American Colleges (1985) strongly advocated that students learn inquiry skills, critical thinking skills, abstract logic thinking skills and the like.

In 1997, the Extended Campus of Embry-Riddle Aeronautical University (ERAU) passed a Faculty Senate motion requiring a learning outcome of enhanced student computing, speaking and writing skills "across the curriculum". The Southwest Region of the Extended Campus went a step further and added critical thinking to this "across the curriculum" (ATC) list.

In spite of nine week terms which do not immediately lend facility to any ATC effort, over 360 Southwest Region courses a year, involving over 5,000 undergraduate and graduate students, require critical thinking learning "across the curriculum". This "CTATC" program is only as successful as the skill of each instructor in creating a critical thinking learning environment in each class taught.

Like many extended campus learning environments of other major colleges and universities in America, Embry-Riddle Aeronautical University's Extended Campus is both similar, yet unique, when compared to all others. The 100-plus resident centers in the US and Western Europe have a five-term-a-year, nine-weeks-per-term academic schedule. Compared to traditional campuses, including the ERAU Daytona Beach and Prescott campuses, accomplishing an "across the curriculum critical thinking" learning environment on ERAU's Extended Campus is very challenging, yet do-able.

Normally taught in either eight or nine class sessions, usually once a week, both undergraduate and graduate courses, no matter what the discipline or specific course content, can be taught in a manner that enhances student critical thinking learning. It is the intent of this paper to provide those Southwest Region faculty and those in attendance at the 2001 Teaching Effectiveness Symposium with a comprehensive and understandable (both faculty and student) set of critical thinking learning tools.

This paper addresses the issue of providing a non-traditional campus critical thinking and information retrieval learning environment in nine-week
courses, and recommends a model called "Applied Critical Thinking". In subsequent chapters, the authors present

a definition of critical thinking, assess current critical thinking programs, discuss the retrieval of information as a critical thinking element, and pose a model for extended campus critical thinking learning.

Chapter II
CRITICAL THINKING ELEMENTS

Few would doubt that the world is becoming increasingly complex, with more words printed in an hour today than it is possible for a single person to read, much less comprehend, in a lifetime. There is an acute and accelerating need for all education institutions to teach, and for all students to learn, critical thinking skills. Undoubtedly, all societies valued some form of knowledge comprehension and transmission from generation to generation.

Sternberg (1986) defines critical thinking as comprising the mental processes, strategies, and representations people use to solve problems, make decisions, and learn new concepts. He states that the study of critical thinking combines the elements of educational, philosophical, and psychological traditions of thought. For purposes of this paper, we will begin our discussion of the educational aspects of critical thinking with the work of Benjamin Bloom and his cohorts, who began their formal work on critical thinking at the American Psychological Association Convention in Boston in 1948.

Bloom's Taxonomy

In 1956, following approximately eight years of two to four day conferences with a group of achievement testing psychologists, Benjamin Bloom published the first of what would become three taxonomies on the cognitive,
affective and psychomotor domains of educational objectives. Sternberg (1986) classifies Bloom's Taxonomy as a taxonomy of critical thinking skills. This first work, titled, Handbook I: Cognitive domain, listed six competency levels, with skills demonstrated at all six levels, from lowest to highest, as follows:

- **Knowledge:**
  - observation and recall of information
  - knowledge of dates, events, places
  - knowledge of major ideas
  - mastery of subject matter
  - question cues:
    - list, define, tell, describe, identify, show, label, collect, name, who, when, where, etc.

- **Comprehension:**
  - understanding information
  - grasp meaning
  - translate knowledge into new context
  - interpret facts, compare, contrast
  - order, group, infer causes
  - predict consequences
  - question cues:
    - summarize, describe, interpret contrast, predict, associate, distinguish, estimate, differentiate, discuss, extend
- **Application:**
  - use information
  - use methods, concepts, theories in new situations
  - solve problems using required skills of knowledge
  - question cues:
    - apply, demonstrate, calculate, complete, illustrate, show, solve, examine, modify, relate, change, classify, experiment, discover
- **Analysis:**
  - seeing patterns
  - organization of parts
  - recognition of hidden meanings
  - identification of components
  - question cues:
    - analyze, separate, order, explain, connect, classify, arrange,

      divide, compare, select, explain, infer
- **Synthesis:**
  - use old ideas to create new ones
  - generalize from given facts

- relate knowledge from several areas
- predict, draw conclusions
- question cues:
  - combine, integrate, modify, rearrange, substitute, plan, create, design, invent, compose, formulate, prepare, generalize, rewrite, conclude, compare, summarize

- **Evaluation:**
  - compare and discriminate between ideas
  - assess values of theories, presentations
  - make choices based on reasoned argument
  - verify value of evidence
  - recognize subjectivity
  - question cues:
    - assess, decide, rank, grade, test, measure, recommend, convince, select, judge, explain, discriminate, support,

Critical Thinking Skills

Sternberg (1986) states that there appears to be a certain core of critical thinking skills that would appear in any reasonably complete list. He uses Gubbins' 1985) unpublished Matrix of Thinking Skills as an example of a list that reflects the critical thinking skills listed by numerous theorists, as listed below.

I. Problem Solving

A. Identifying general problem

B. Clarifying problem

C. Formulating hypothesis

D. Formulating appropriate questions

E. Generating related ideas

F. Formulating alternative solutions

G. Choosing best solution

H. Applying the solution

I. Monitoring acceptance of the solution

J. Drawing conclusions

II. Decision Making

A. Stating desired goal/condition

B. Stating obstacles to goal/condition

C. Identifying alternatives

D. Examining alternatives

E. Ranking alternatives

F. Choosing best alternative

G. Evaluating actions

III. Inferences

A. Inductive thinking skills

1. Determining cause and effect
2. Analyzing open-ended problems
3. Reasoning by analogy
4. Making inferences
5. Determining relevant information
6. Recognizing relationships
7. Solving insight problems

B. Deductive thinking skills

1. Using logic
2. Spotting contradictory statements
3. Analyzing syllogisms
4. Solving spatial problems

IV. Divergent Thinking Skills

A. Listing attributes of objects/situation

B. Generating multiple ideas (fluency)

C. Generating different ideas (flexibility)

D. Generating unique ideas (originality)

E. Generating detailed ideas (elaboration)

F. Synthesizing information

V. Evaluative thinking Skills

A. Distinguishing between facts and opinions

B. Judging credibility of a source

C. Observing and judging observation reports

D. Identifying central issues and problems

E. Recognizing underlying assumptions

F. Detecting bias, stereotypes, clichés

G. Recognizing loaded language

H. Evaluating hypotheses

I. Classifying data

J. Predicting consequences

K. Demonstrating sequential synthesis of information

L. Planning alternative strategies

M. Recognizing inconsistencies in information

N. Identifying stated and unstated reasons

O. Comparing similarities and differences

P. Evaluating arguments

VI. Philosophy and Reasoning

A. Using dialogical/dialectical approaches Scientific Research/ Reasoning Collins and Onwuegbuzie (2000) use the idea of higher critical thinking as enhancing learning in research methodology courses. They mention the work of Burns and Grove (1987), who hold that a five stage scientific reasoning process is involved in critiquing a research article. The first stage involves identifying the study's elements and understanding the nature, significance and meaning of both implied and explicit components. This can be likened to the analysis component of critical thinking.

The second stage of Collins and Onwuegbuzie (2000) article critiques involves the interpretation of the theories and concepts in the report consistent with the report authors. This is likened to the interpretational aspect of critical thinking. The third stage involves knowledge of each aspect of the research process to determine the extent that the article followed the process. This is likened to the evaluation skills associated with critical thinking.

The fourth stage involves identifying the expressed and unexpressed assumptions of the study (Collins & Onwuegbuzie, 2000). This is seen as parallel to the explanatory aspect of critical thinking. Last, conceptual clustering that maximizes the meaning of the research findings, is seen as parallel to the inferential aspect of critical thinking, as well as with other critical thinking facets.

According to Schwartz, Slate and Onwuegbuzie (1999), action research involves an eight-step cyclical process: (a) identifying an issue or problem to investigate; (b) gathering and reviewing relevant literature; (c) formulating

research questions and/or hypotheses; (d) developing a research plan; (e) implementing the research plan; (f) analyzing the data and interpreting the findings; (g) communicating the findings; and (h) repeating the research cycle with a modified problem derived from what was learned. These eight phases each appear to involve at least one of the cognitive skills associated with critical thinking. In their research, higher critical thinking skills, whenever acquired, resulted in significantly greater research methodology education skills.

It is apparent that there are significant parallels between both the critical assessment of relevant literature and research methodology skills, and critical thinking precepts. Higher critical thinking skills equaled higher research methodology functioning.

CHAPTER III

CRITICAL THINKING PROGRAMS

According to Sternberg (1986), critical thinking programs have been around for thousands of years. These programs have been known as "logic" courses, and at the college level, these courses are usually taught in the philosophy department.

The Copi (1978) text for courses in logic has gone through five editions. Copi's course consists of three parts: use of language in logic, deduction and induction. While there may not be a substitute for the full power of the philosophy discipline in this type of course, there is also incomplete training on critical thinking. Life is much more pragmatic and flexible than the rigid rules of logic that apply best to structured situations.

Bransford and Stein (1984) have developed a course called the ideal problem solver, where IDEAL is an acronym for Identifying the problem, Defining and representing the problem, Exploring possible strategies, Acting on the strategies, and Looking back and evaluating the effects of one's activities. A 150 page, eight chapter paperback covers (1) the importance of problem solving; (2) the model for improving problem solving; (3) improving memory skills; (4) learning with understanding; (5) intelligent criticism; (6) creativity; (7) effective communication; and (8) concluding remarks.

Sternberg (1986) teaches a course called Understanding and Increasing Intelligence: A Triarchic Program for Training Intellectual Skills. Normally taught ideally as a yearlong course, Sternberg's course teaches for transfer of knowledge, energizes both teachers and students, and emphasizes the training of both metacomponents (systems), as well as performance and knowledge-acquisition components.

Logan (1987) teaches critical thinking by using what she calls the Scientific Process as a model system. Her general plan is to identify and clearly define critical thinking skills for students, model them, and give students frequent feedback by describing what they are doing and evaluating it. Logan mentions that an important element of critical thinking is the development of an attitude to "want" to reason. According

to Logan, the Scientific Process is a method for evaluating observations and experiences in the world in order to discover underlying principles that govern nature. It is a "strong-sense" critical thinking process since the student must ask questions such as: "Is the evidence sufficient to allow this conclusion?"; "Is this the only conclusion that this evidence supports?"; and "Is the evidence reproducible and reliable?"

Hannel and Hannel (1998) mention that two impediments stand in the way of helping students to become critical thinkers: a widespread misdiagnosis about why students fail to become critical thinkers in the first place, and the lack of a practical instructional strategy for teaching critical thinking skills in the classroom. They pose a seven-step model for teaching critical thinking.

1. Look at the information (label or identify). Having students identify what they see (what the issues are) provided early clarification of the issues.
2. Seek similarities and differences (compare/interrelate/analogize). Socratic questioning by the teacher elicits parallels and contrasts.
3. Find overall themes or relationships (classify/integrate/pre-summarize). Socratic questioning is done by the teacher to achieve classification, and begin to summarize.
4. What do we do now? (decode/deduce). The teacher asks Socratic questions to help the students decode the class-specific information or requirements.
5. Answer correctly (encode). The teacher asks Socratic questions to have students logically defend or discard their tentative answers.
6. Apply to similar situations (infer/project/apply). The teacher asks the students to compare the course information or process to real life situations, perhaps in their professional work.
7. What have we learned? (summarize). This helps to sharpen the student's understanding of what was just learned.

Spencer and Angus (1998) mention that in the California State university system, the importance of higher-level literacy skills is being directly addressed by requiring students to take a class on critical thinking as part of their undergraduate education. They teach a class called Critical Reading as Critical Thinking. In this course, students focus on developing and applying reading skills in the interpretation, analysis, criticism and advocacy of ideas encountered in academic reading. Their work is largely fashioned after the critical thinking writings of Paul and his associates (Paul & Binker, 1991). Critical thinking is describes as having two components: a set of cognitive skills to process information and construct new ideas and beliefs; and a disposition towards using critical thinking skills to guide behavior.

Through the use of small and large group presentations of reading assignments, Spencer and Angus (1998) have their students model what they have learned through their reading assignments. Critical thinking is seen as essential to higher order reading skills.

CHAPTER IV
APPLIED CRITICAL THINKING

Developed over the past three years as an experience within the creation of a critical thinking "across the curriculum" model in Embry-Riddle Extended Campus classrooms in the Southwest Region, this Applied Critical Thinking model is based on course learning outcomes and syllabus demands. As the course learning outcomes are all partially based on Bloom's Taxonomy, there is a solid critical thinking base.

Each ERAU course outline has a set of learning outcomes, developed by a course monitor, normally a subject matter expert in this discipline or field. In addition, every individual instructor or professor who teaches this course establishes a schedule and specific way of achieving each course learning outcome. Students learn what each individual course learning outcome and schedule-specific learning situation is required, as the instructor uses the **knowledge, comprehension, application, analysis, synthesis and evaluation** language of Bloom's Taxonomy. As was discussed earlier in this paper, Bloom's Taxonomy can also be viewed as an educational critical thinking taxonomy.

There is a subtle, yet open movement from course learning outcomes and demands to that of the course discipline, then, finally, to real life situations, perhaps at work. This three-part critical thinking learning schema is intended primarily for those students who have not yet developed their own personal critical thinking schema, but it also appears to work well with more "critical thinking mature" students as well.

Course Demands/Critical Thinking Elements

As an example of this process, consider a graduate course in research methods and statistics, similar to a situation described in the previous chapter. After detailing the course syllabus and learning outcome demands, each one is explained in detail, as a part of a continuous sequence. If the choice of research topic changes during the nine week course, the graduate students fall back on their knowledge of the process, and are able to synthesize a new schema, patterned both after the process and the new research topic. Consider the following steps in the ERAU graduate research methods and statistics course:

- Select a research problem (topic)
- Review relevant literature and research
    - Develop key word descriptors
    - Choose reference location/repository
    - Collect XX abstracts
    - Collect hard copies of pertinent abstracts
    - Critically analyze references/research materials
- State a tentative hypothesis or research question
- Choose a research method
- Choose a research plan
- Select a population/sample

- Select/construct a data collection device
- Begin to write the proposal in Graduate Research Project /APA style
- Critique/revise data collection device
- Learn/practice descriptive statistics
- Learn/practice inferential statistics
- Select GRP Committee members
- Complete GRP Proposal
- Present research proposal (as a RFP response)
- Collect/analyze data
- Write final GRP report

As can be seen from the short, unexpanded list of course and syllabus demands and learning outcomes above, there are many course critical thinking elements to be solved. All are openly discussed in class as critical thinking elements of the course.

Transposing Course Demands Into Academic Discipline and Work Applications

As course learning outcome and syllabus requirements are satisfied, a transposition from the course to the discipline can be accomplished through Socratic questioning. In the case of research methodology, it can be postured that there will be countless opportunities for additional scientific research modeled after the steps on the previous pages, as questions arise at work concerning unknown situations requiring casual or rigorous analysis. It can also be postured that there will be times when the steps will have to be shortened, or modified, as time and circumstances might not permit the sterile timeframe of the nine week research methods course.

Finally, it can be suggested that the critical thinking steps and process used in this course can be used as a lifelong skill for problem solving. In the following chapter, the critical thinking skills required for information location and retrieval are discussed, both as a critical element of the research process described above, and as a personal skill set to be applied in any conceivable situation.

CHAPTER V
INFORMATION RETRIEVAL AND COMPUTER TECHNOLOGY

A study conducted at Alice Lloyd College in Kentucky (Murray & Graham, 1996) illustrates how instruction in critical thinking skills can be applied in any college course containing a research component. The authors integrated instruction in database searching and critical thinking skills into an undergraduate educational psychology course. Instruction included a one-hour session on effective use of the ERIC database, including use of the ERIC Thesaurus, critical analysis of citations and abstracts, advanced searching with Boolean operators, and limiting citations.

Students were also provided with two classroom sessions covering critical thinking concepts and systematic planning for decision-making. Students were asked to solve a research problem posed by the faculty member, and, in

order to succeed in solving the problem, they were required to use critical thinking processes, applications of systematic planning, and technological applications which were taught during the classroom sessions.

During the course of instruction, students were asked to define and investigate a problem, develop a rationale, construct search strategies, compile descriptors, search the ERIC database, and connect relationships of citations to the educational topic or problem they had identified. They also were required to review citations, summarize the data collected, draw conclusions, and make recommendations and propose potential solutions to the problem. Students worked collaboratively in searching the database, and they produced an annotated bibliography at the end of the course. The emphasis of the course, in both the database searching and problem-solving sessions, was the development of higher-level critical thinking processes (analysis, synthesis, and evaluation) delineated in Bloom's taxonomy.

Murray and Graham (1996) emphasize that instruction in the use of any database develops problem-solving and analytical skills as a knowledge base, which can be transferred to other learning situations – research assignments at the undergraduate or graduate level, workplace problems requiring solutions, and life in general.

Murray and Graham (1996) provide a table of Bloom's Taxonomy by Cognitive Categories Linked to Learning Descriptors and Activities (Figure 1) that supports the development of critical thinking skills at various levels by students participating in database searching and critical thinking research projects.

Figure 1.

The descriptors and learning activities provided by Murray and Graham can serve as a basis for teaching applied critical thinking skills across the curriculum.

Murray and Graham (1996) conducted both summative and formative evaluations of the critical thinking and database-searching project and made improvements throughout the course of the study. Several components of the evaluation process were noteworthy:

1. The majority of participants in the project (more than 80%) had very little previous computer or bibliographic searching experience.
2. More than 90% of the participants in the project rated the overall relevance and value of the classroom and library instruction sessions as good to excellent.
3. When asked to state their opinions on the value of search components as they related to problem solving, 98 percent of the participants in the project agreed that learning to define an instructional problem was of the highest value, but developing a rationale for an instructional topic was also very significant. Over 85 percent of the students also placed a high value on

constructing a search strategy and organizing descriptors into logical groups, connecting relationships of citations to the topic or problem, and examining the problem through analysis of the meaning and content of citations.

4. Participants identified the strengths of the project as relating to skills development through hands-on bibliographic searching activity and opportunities to work through a problem solving process. They recognized that these skills and learning experiences in developing systematic thinking processes and identifying and analyzing information resources could be transferred to other courses, as well as to experiences beyond the classroom.

5. Students also recognized the value of computer literacy skills in general and their applicability to a number of different fields beyond education. They concluded that conducting an online search was not really difficult at all when approached as a systematic, logical process. Instruction in Bloom's cognitive hierarchy and hands-on activity related to critical thinking processes allowed students to draw correlations between searching activity and problem solving supported by technology.

Although the study by Murray and Graham (1996) serves as an example of current practices involving faculty and librarian collaboration, it is certainly not the only instance of such activity. Bibliographic instruction has been integrated into classroom instruction since the 1970s.

Walter et al. (2000) cite several examples of faculty and librarians working together to create course-integrated instruction in database searching and critical thinking skills. Exemplary programs at Earlham College, Indiana University-Purdue University at Indianapolis, Evergreen State College, the University of Washington, and the Virginia Polytechnic Institute and State University serve as benchmarks for other institutions attempting to develop a collaborative teaching model of faculty and librarians working together to create instructional objectives appropriate to the information age.

Gallegos and Wright (2000) provide further examples of case studies in collaboration, and Ward and Cook (2000) have created a directory of electronic resources (web sites) detailing instances of librarians and faculty working together to overcome the problem of information overload through the development of new instructional paradigms that include critical thinking and information retrieval skills.

In response to these kinds of initiatives and the criteria mandated by the Southern Association of Colleges and Schools (SACS), the Embry-Riddle Extended Campus should certainly consider establishing a curriculum-based program in information literacy and critical thinking skills utilizing the instructional skills and experience of its faculty and reference librarians. According to the Center for Critical Thinking at Sonoma State University, the components of a good program should include teaching content as a mode of thinking, involvement of students in an active learning process,

and reasonable access to information and established criteria against which they can assess their thinking and its potential.

Such a program should also focus on well-formulated questions or problems and should address real-life problems through engagement in technological applications. A program meeting these criteria would, by definition, involve students in higher-level cognitive processes.

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

It is apparent that Bloom's Taxonomy fits the educational triad of Sternberg's (1986) critical thinking triad, and can be considered as an appropriate educational critical thinking tool. Apparent, also, is the need for applications in critical thinking across the curriculum, instead of in special classrooms where only critical thinking is discussed. There would be a special advantage to having all faculty trained to teach critical thinking skills to their students.

There appear to be many ways to teach critical thinking in classrooms, but not all would work in ERAU Extended Campus classrooms over a nine week course meeting eight or nine times. Applied Critical Thinking, or another critical thinking teaching/learning schema needs to be developed more fully, and offered across the width and breadth of ERAU's Extended Campus.

Critical thinking applications relating to information location, retrieval and analysis appear to be as important as those involving only the course syllabus demands and learning outcomes. As specified in accrediting agency "must" statements, information location and retrieval by faculty and students in a variety of media and applications is a critical element of adult literacy in the 21st century.

Recommendations

It is recommended that the ERAU Extended campus adopt "critical thinking across the curriculum" as a course outline learning outcome in every Extended Campus undergraduate and graduate course. It is also recommended that information location and retrieval skills, preferably from the ERAU Hunt Library, also be required as a course outline learning outcome in every Extended Campus undergraduate and graduate course.

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