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ABSTRACT

Critical thinking encompasses the recognition of significant problems within a particular knowledge domain, the ability to systematically evaluate data through the application of various schema, the ability to suspend personal evaluative biases, and the ability to construct, test, and communicate a final solution. Critical thinking is a skill which most educators expect their students to master, but, unlike reading, writing, or programming, critical thinking is viewed as something which one discovers for oneself. The best students do seem to acquire critical thinking skills without explicit instruction, but many students require more explanation and coaching. Many current attempts to teach critical thinking, including unstructured Piagetian thinking exercises, the Socratic method, and structured courses focusing on either domain-specific skills or general skills to be applied across the curriculum, have not produced the desired result. Various research models, focusing on artificial intelligence; comparisons of expert and novice information processing; logical biases responsible for some systematic errors in logic; and the self-referent effect, offer insight into the complicated process of human thought. Using these insights, a program, course, or technique may be developed for testing. (AYC)

POLICY ISSUES AT THE COMMUNITY COLLEGE:

ESSAYS BY FELLOWS

IN THE MID-CAREER FELLOWSHIP PROGRAM

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IMPROVING STUDENT THINKING AT THE COMMUNITY COLLEGE

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Critical thinking is a skill which most educators expect their students to master, but unlike reading, writing or programming very little direct instruction is ever provided. Critical thinking is viewed as something which one discovers for oneself, something which matures with time and exposure to the appropriate stimuli, something which is merely an extension of everyday thinking.The Socratic approach illustrates these presumptions; if the teacher asks the right questions, the students will recognize relationships, identify the direction of the probe, and most importantly experience insight into the problem and its solution. However, no one is sure exactly how this mysterious process takes place.

What is certain is that for many students it doesn't take place; they require more--more explanation, more coaching, more something. The best students do seem to acquire critical thinking skills without such explicit instruction, but even they may experience difficulty in translating problem solving skills from one area to another, even one which is similar (Riley, Greene & Heller, 1983; Kieras & Bovair, 1986). All students who have some difficulty with critical thinking demonstrate a systematic (if erroneous) approach rather than haphazard errors (Resnick, 1985). The latter would indicate confusion while the former suggests that even students who are considered poor problem solvers are practicing a form of logic which offers a foundation for improving thinking skills. Thus, the consensus that we ought to "teach" critical thinking (N.J. Basic Skills Council, 1986).

This conclusion, interestingly, is symptomatic of one of the major errors in critical thinking, to seek a solution before one defines the problem and decides what questions should be asked. Redefining the question and identifying the underlying assumptions and implicit knowledge requirements is one of the problem solving strategies which seem to account for the greater success and apparent ease of "expert" critical thinking (Chi, Feltovich & Glaser, 1981). An "expert" would ask: What is critical thinking? What do we already know about successful and problematic approaches? What do we want our students to be able to do, to do differently, or to do better? What is the best strategy for accomplishing this? By the time we sort out answers to our earlier questions, the answer to the last (i.e. how to teach critical thinking) should become apparent (i.e. insight should occur), and perhaps we also will have learned how to model critical thinking more explicitly for our students.

The above questions will not be fully answered in this paper, as the task of simply surveying the diverse research on thinking strategies is greater than an article of this length permits. However, I will attempt to redefine the problem to some degree and identify some of the current work relevant to the goal of improving critical thinking, to offer some suggestions for future exploration.

The first question to be raised is: What is critical thinking and how does it relate to other thought processes? The ability in question has been variously labelled as problem solving, logical, academic or critical thinking (Henle, 1962; Presseisen, 1986). However, the accompanying descriptions of process and function are congruent indicating these may be treated as the same skill rather than as different types of thinking. To simplify matters, I will refer to all of the above as critical thinking. Critical thinking encompasses the recognition of significant problems within a particular knowledge domain, the ability to systematically evaluate data through the application of various schema or potential solution plans and empirically check the reasonableness of each, the ability to suspend personal evaluative biases, and the ability to construct, test and communicate a final solution.

Several researchers (e.g. Bobrow & Brown, 1975; Chi, Feltovich & Glaser, 1981; Resnick, 1985) propose that critical thinking combines both top-down (schema-driven) and bottom-up (data-driven) processes in complementary cycles although the balance between these two approaches may determine the degree of success to some extent. In comparison of expert and novice problem solvers, Chi, Feltovich & Glaser (1981) have attributed the experts' greater success to more emphasis on identifying underlying schema or principles in outlining a solution (i.e. top-down); in contrast, novices stick very close to the data and derive more superficial solutions (i.e. bottom-up).

Underwood (1952), Henle (1962), Lawler (1981) and the N.J. Basic Skills Council (1986) express the belief that critical thinking differs in important ways from those thinking skills we utilized daily. Henle best sums up this difference. Logical thinking is an ideal, a criteria against which we evaluate other forms of thinking. It is how we "ought" to think, but it is not how we actually think in daily "real world" activities. In the "real world" we are biased: we allow our emotions, motivations, and intuitions equal time with our more rational functions, and if we perceive the world the way we wish it to be, or act upon our feelings, or stress "what makes sense" within our phenomenological sphere, we may be no less (and perhaps more) effective than if we dealt with the world within an objective, logical framework. For if we know ourselves to be occasionally irrational and illogical, we know that others often are so: thus, we deal with people (including ourselves) as they are rather than as they might be or as we would wish them to be (i.e. rational).

In contrast to this imperfect world, we seek to create a more idealized world in academia. We try to structure, to define, to manipulate or experimentally control, to discover the fundemental principles of our respective disciplines and those conditions capable of altering basic rules. As we try to be more critical and precise in our scholarship, we stress those qualities associated with logical or critical thinking (Presseisen, 1986; N.J. Basic Skills Council, 1986) and ask our students to do something different from what common place activites require.

If we accept the assumption that critical thinking differs from other more common thinking skills. and is not easily abstracted from experience by many students, the next question we must raise is: Can critical thinking be taught and if so, how should we approach it? Both the N.J. Basic Skills Council (1986) and Presseisen (1986) list current attempts to teach critical thinking. These approaches, which include unstructured thinking exercizes (a la Piaget), the Socratic method, and structured courses focusing on either domain-specific skills or general skills to be applied across the curriculum, have not produced the desired results.

Unstructured Piagetian exercizes have failed to instruct the average student in those skills which a Piagetian would label formal operations (i.e. logical or critical thinking). Sixty per cent or more of the population are assigned to the concrete operational level, unable to utilize critical thinking skills. However, further investigation suggests that this may be a superficial and limited analysis, that people may progress on to formal operational skills, but only in areas of specialization or narrowly-defined interest (Stevens-Long, 1984). This means that in those areas of expertise where students are more rigorously and specifically instructed, formal operational skills (which usually do not generalize to other academic areas) may be achieved. Still individuals may be typed as concrete operational if not tested in their area of expertise. Is this merely a testing problem or do such rigid domain-specific skills fall short of our prototype of the critical or logical thinker?

The Socratic method as previously mentioned seems to rely on the ability of the student to abstract a method of critical evaluation to be generalized later to other subject matter from hints (i.e. teacher initiated questions) which often seem to go unrecognized by students.

The verdict on structured thinking courses (either general or domain-specific) is still out because frequently such courses have merely recycled techniques which we have found to be ineffective or partially so. The question remains: Can we offer our students who are unable to extrapolate from the abstract a more explicit coaching format? How do we do this? Is there anything new we haven't tried?

Resnick (1985) cites a number of research studies which suggest different perspectives and perhaps some new strategies. These include artificial intelligence (AI) models and comparisons of expert and novice information processing.

Artificial intelligence studies seek to develop computer programs which can "think" or "solve problems" and generate models of human information processing (e.g. SCA (Bobrow & Brown, 1975), ACT (Anderson, 1982), ABLE (Larkin, 1986), SOAR (Laird, Rosenbloom & Newell, 1986)). Such programs are detailed simulations of human thinking which attempt to model how knowledge is structured and accessed and what procedures and heuristics are used in manipulating it.

AI studies the process of building coherence (or linking information, recognizing missing propositions and infering them), memory storage and retreival including capacity, operating time and automaticity, schema or prototype formation and usage, both top-down and bottom-up organization strategies and their interplay, syntax (i.e. rules) and semantics (i.e. symbolic representation), and systematic errors and complementary "repair programs". Earlier research in this field focused on knowledge-poor task environments (i.e. a minimum information not provided within the problem statement was necessary) and sought to develop general domain-independent methods. More recently AI studies have included more domain-specific situations and have questioned the versatility of general rules.

While no model has achieved complete success, each seems capable of explaining a part of the complicated process of human thought, and such simulations (e.g. Gick & Holyoak, 1983; Riley, Greeno & Heller, 1983; Burnstein, 1986) also shed some light on systematic errors in logic; in general, these errors seem to be the result of either incorrect procedures which are variants of correct ones (i.e. incorrect rules sometimes called malrules or "buggy algorithms" because of their similarity to malfunctioning computer programs which require debugging) or incomplete or faulty understanding of the problem statement (i.e. a communications breakdown). The recognition that computer generated models can duplicate human errors without producing additional ones unrepresentative of human thought offers some support for both the validity of the simulations and the assumption that "illogical" thinking does follow a pattern which if understood might assist in learning to recognize and correct such errors or "debug" a student's faulty logic.

Comparisons of experts' and novices' critical thinking behavior in a variety of domains such as mathmatics (Lawler, 1981), physics (di Sessa, 1982; McCloskey, 1983), politics (Fiske & Kinder, 1982), baseball (Chiesi, Spilich & Voss, 1979) and chess (Newell & Simon, 1972) may provide a different model for instuction in critical thinking and answer the question: What do we want our students to be able to do?

First, the expert/novice model highlights the importance of domain-specific knowledge; the expert always knows more facts, more relationships between facts and more previously successful solutions than the novice. Although quantity and quality are inextricably linked and together may explain the difficulty in transfering critical thinking skills from one domain to another and the domain related differences in testing for formal operational thinking, how the expert organizes this information seems more significant than its quantity alone.

The expert's greater knowledge may result in tighter organization which may increase the capacity of working memory (STM) and thus, the problem solvers ability to consider and compare a variety of relevant though seemingly inconsistent facts simultaneously and develop broader schema or problem solving strategies. In contrast, a novice who requires more space in the STM for less organized information also may require more time to process relevant data which necessarily must be done in cycles which try different permutations but can never include all the relevant information at the same time (i.e. contiguously). Thus, the novice may never see a vital relationship necessary to solve the problem. This suggests one explanation of why novices both take more time to solve a problem and sometimes miss the critical linch pin of a solution (Fiske et al., 1983)

Experts also may recognize relevant variables more quickly because of their greater familiarity with the domain and greater confidence in their retreival skills. Chi et al. (1981) found that while experts and novices produced similar results when asked to circle the key concepts in a problem statement which could contribute to a solution, experts circled fewer key words showing greater selective recognition of the problem requirements.

Similarly, Reder & Anderson (1980) propose that experts may have more previously completed solutions stored in memory and are able to produce these answer units readily while novices must build them and that due to recognition of correlations, experts create stronger associations when facts are stored in memory, and these stronger associations result in more efficient retreival and thus, shorter reaction times. Chiese et al (1979) report that experts were able to recognize relevant changes or new material in a problem statement more often and required less information to make recognition judgments than did novices.

In addition to tighter organization and the resulting more efficient storage and retreival, experts also exhibit a different approach in organizing the problem space (i.e. defining the question(s) to be answered, relevant data, and any contextual restraints). Chi et al. (1981) cite differences between experts and novices in the four stages of representation originated by McDermott & Larkin (1978): 1) literal representation; 2) naive representation; 3) scientific representation; and 4) algebraic (or symbolic) representation. Novices fixate on the first two stages with some attention occasionally given to stage 3; they stress the importance of the terms used in the problem statement, propose solutions which literally include them, and look for a strategy which will link the two, sometimes without any real understanding of how or why; these solutions are often referred to as naive theories (e.g. McCloskey, 1983). This also might be illustrated by the math student who has the problem, thinks he knows what the answer should look like and is seeking the intervening calculations.

In contrast, experts focus on stages 3 and 4; they attempt to categorize the problem according to their knowledge of the domain. Rather than focusing immediately on the solution (i.e. What's the right answer?), they focus on the problem statement and ask: What do I need to know to solve this problem? Is all the information available in the problem statement or do I need to add information (from my own knowledge base) which the question implies or assumes I will recognize the need for? What principles or strategies from my past experience with the domain are needed to answer the question?

In this fashion the expert uses his greater domain-specific knowledge and experience to reorganize the problem statement: this transformation adds derived (or second-order) features which the novice doesn't access, and these added features usually clearly plot the solution path so that the answer then becomes obvious (i.e. insight occurs). Meanwhile the novice often is stuck with apparently conflicting facts or a solution strategy which "makes sense" intuitively but can't encompass all the data or doesn't quite fit which is very frustrating because the novice knows that answer has to be right, is the only possible one (closure) and thus, continues to plod along in the face of illogic and "obvious" error.

While these descriptions may infer that experts use top-down or schema-driven organizational strategies exclusively and novices are limited by a bottom-up or data-driven approach, Chi et al., 1979) suggest that the expert uses a combination of both strategies which increase effectiveness. One possible difference proposed by Chiesi et al. (1979) is the problem's goal structure.

Novices ignore or are unaware of this, and experts use it as an evaluation criterion. By keeping sight of the goal of the problem and continually checking new information and potential strategies against it, the expert is creating an interaction between the problem and the knowledge base which taps both declarative (i.e. factual) amd procedural (i.e. what to do with it) knowledge and monitors the development of schema for omissions and faulty strategies.

Thus, identifying and modeling expert problem solving strategies if combined with an emphasis on metacognition.(i.e. self-monitoring) to heighten awareness of what the thinker is doing and what he or she should be doing could improve critical thinking skills; however, this approach would limit itself to domain-specific courses and would not support teaching across the curriculum.

In addition to the two areas of research detailed above, there are several others of potential interest. Space allows only a breif mention of two examples: logical biases responsible for some systematic errors in logic and the self-referent effect, in particular, which offers some insight into differences between individuals in interpreting the problem statement, encoding and retreiving information, and judging the relevancy of propositions.

Logical biases which have been identified are: a tendency toward closure (i.e. excluding alternate solutions in favor of only one probable solution too early in the evaluation process), a tendency toward verification once a strategy is selected (which makes it difficult to replace an unsuccessful strategy), a tendency toward similarity, the atmosphere effect (responding with a positive solution to positively stated propositions and with a negative solution to negatively stated ones, especially in the case of a double negative), a tendency to seek causality, a tendency to weight emotionally charged propositions, a tendency to remember material one has added as part of the original problem statement, a tendency to consider goals, outcomes, and motives as central to understanding a problem, a tendency to confirm expectancies based on past experiences, and the self-referent effect (a tendency toward egocentrism). The last is of particular interest in psychological reasoning as potential self-referent material is heavily represented in psychology course content.

Rogers, Kuiper & Kirkes (1977), Markus (1977), Bowerman (1978), Bower & Gilligan (1979), Lord (1980), Mancuso & Ceely (1980), and Marks (1984) offer more insight into the self-referent effect, and Janis & Frick (1943), Morgan & Morton (1944), Lefford (1946), Thistlethwaite (1950), Henle (1955), Henle & Michael (1956), Gough (1965), Jones (1966), Wason (1968), Green (1970), Evans (1972), and Wason & Johnson-Laird (1972) explore one or more of the above logical biases.

While this paper may not detail an answer to how we teach critical thinking, I believe it may help to flesh out some of the questions regarding what we wish to accomplish and what we might try as alternatives to what we've been doing. A critical thinker has to select out and organize the relevant data (which I have initiated) and then construct a representation of the problem (which I am in the process of doing) and finally instantiate a solution (i.e. a program, a course, a technique) to be tested. Only in the application of potential teaching strategies can we learn their value. (This is the eventual goal of this paper.) Recent articles (e.g. Presseisen, 1986; N.J. Basic Skills Council, 1986) have raised the questions of the need and justifications for critical thinking and have surveyed the current status of the teaching of critical thinking. Perhaps, this article may offer some alternative suggestions regarding the next step to be taken.

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