Teaching Critical Thinking with Electronic Discussion

Steven A. Greenlaw and Stephen B. DeLoach

Abstract: One of the products of a liberal undergraduate education is the ability to think critically. In practice, critical thinking is a skill that economics students are supposed to master as they complete their studies. However, exactly what critical thinking means is generally not well defined. Building on the literature on critical thinking, the authors examine how electronic discussion can be used effectively to teach this skill. Because of the multiplicity of views expressed, the asynchronous nature of the technology, and the inherent positive spillovers that are created, electronic discussion appears to provide a natural framework for teaching critical thinking.

Key words: class discussion, critical thinking, distance learning, electronic discussion
JEL code: A2

One of the products of a liberal undergraduate education is the ability to think critically. This should be particularly true for economics students who, after all, are ostensibly taught the discipline's version of critical thinking—the economic way of thinking. It is ironic then, that relatively little has been published on effective strategies for teaching critical thinking in economics.[1] This is not an original criticism. In his seminal article on research in pedagogy, Fels (1969) identified critical thinking as an area ripe for teaching and exploration by economists. Fels's critique, "rarely is a concerted effort made to get students themselves to wrestle with thorny issues," is still quite relevant today (p. 8).

Our purpose in this article is to introduce electronic discussion as a method of developing critical thinking skills in undergraduate economics students. Although previous innovators of critical thinking pedagogies have largely concentrated on either writing or in-class discussion, the medium of electronic discussion also appears to be particularly well suited for this task. Electronic discussion can be defined as any collaborative class activity organized to explore an issue, using an electronic medium such as electronic mail or Web-based discussion lists. Electronic discussion provides a natural framework for teaching critical thinking because it captures the best of both traditional writing assignments as well as in-class discussions. Cohen and Spencer (1993) argued that writing is essential for critical thinking because the students learn how to develop arguments supported by logic and evidence. Alternatively, Hansen and Salemi (1990)

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claimed that in-class discussion is a vital active-learning strategy because of the inherent dynamics. In particular, unlike writing assignments, discussion forces students to confront multiple alternative viewpoints.

Working from the premise that to teach critical thinking effectively in economics we must be able to define it, our first task is to develop a valid taxonomy of skills that is built solidly on the critical-thinking literature.[2] We then address why electronic discussion can be an effective medium for developing such skills. Following that, we explain in detail precisely how we have implemented electronic discussions, specifically Web-based threaded discussions, in our courses. We conclude by describing our experience with the numerous electronic discussions we have conducted.

DEFINING LEVELS OF CRITICAL THINKING

To effectively teach critical thinking, an instructor must first be able to define it in ways appropriate to both the field of study and the medium to be used. To that end, we begin by explaining the taxonomy we have developed for teaching critical thinking in economics.

It is a long way from Perry's (1970) abstract schema to actually rating student postings on an electronic discussion of macroeconomic issues. At least two major hurdles need to be overcome: first, modifying the existing schemas to work in the context of electronic discussions; and second, dealing with the significant difficulties involved in deriving reliable and valid measures of the various levels of critical thinking. Peterson and Bean (1998) observed that assessing the effectiveness of critical thinking programs can be difficult within disciplinary courses in which these goals must be blended with course content goals. Similarly, Thoma (1993, 133) noted that "research faces formidable problems of measurement and interpretation because the results involve qualitative changes in thinking and complex interactions between thinking and value formation."

Synthesizing the critical thinking literature, we have developed a scale for measuring the levels of intellectual activity in an electronic discussion.[3] Our taxonomy (summarized in Table 1) focuses on evaluating *how* students argue. Students can take a position or make an argument with differing degrees of sophistication. These range from arguments that are based on (1) unsupported assertions; (2) anecdotal evidence; (3) an explicit logic, although lacking in depth or complexity; (4) economic theory; (5) theory supported by empirical evidence; and (6) value judgments based on appropriate disciplinary criteria, such as equity and efficiency. As students progress up the taxonomy, they go from presenting simple facts (levels 1 and 2), to making an explicit argument (level 3), to drawing a conclusion (levels 4–6).

In the remainder of this section, we define and explain our levels of critical thinking. Examples from student postings, complete with misspellings and bad grammar, from discussions held during the spring semesters of 1999 and 2000 can be found in Appendix A.

At level 1, student answers are limited to what McDaniel and Lawrence (1990) called *Unilateral Descriptions.* Students define terms, paraphrase information, and restate the question but add little or nothing new to the issue or question. At

this level, they often define relevant terms or repeat information that has been previously posted. Sometimes, they simply give as an answer a paraphrase of the question. Their postings may also include simple "good" or "bad" statements, such as, "I agree."

Next, students take a side but do not explore other alternatives. In other words, they make unsupported assertions or simplistic arguments. Level 2 is what McDaniel and Lawrence have termed *Simplistic Alternatives*. Although students make assertions, they fail to construct a logical argument. One explanation for this behavior is that they do not recognize conflicts with opposing views and, as a result, fail to explore them. Sometimes, they may simply be clarifying a previ-

TABLE 1
Greenlaw-DeLoach Taxonomy of Critical Thinking

Level	Student position
Level 0	Off-the-subject or otherwise unscorable
Level 1[a] Unilateral Descriptions	Students paraphrase information, they repeat and restate the question Define terms Simply repeat information Simple "good" or "bad" statements Add little or nothing new to the issue or question
Level 2[b] Simplistic Alternatives/ Argument	They take a side, they do not explore other alternatives, they make unsupported assertions, they make simplistic arguments An assertion, without evidence, often in the form of a question that modestly advances thinking; often synonymous with getting the discussion back on track Challenge an assertion but without evidence Facts (beyond defining terms) relevant to the discussion but no argument, per se Simple explanations, e.g., giving an example Cite simple rules, "laws" as proof Do not address conflicts with opposing views or do not explore them
Level 3[c] Basic Analysis	They make a serious attempt to analyze an argument or competing arguments and evaluate it/them with evidence Appeal to a recognized (appropriate) authority Casual observation, anecdotal, datum (vs. data) Assertions with explicit evidence offered; or a reasoned challenge of another's assertion but without a clear logical framework A singular, Socratic-style question Often list numerous factors as evidence but do not integrate them within a logical framework No clear conclusion or choice between alternatives is made; e.g., when pressed for the "best" explanation, they respond that both are equally valid
Level 4[d] Theoretical Inference	They employ the use of (economic) theory to make a cohesive argument Logical statements based on the discipline's accepted model/school(s) of thought Identify assumptions Challenge a key assumption of another's theory A series of logical, Socratic-style questions

(table continues)

TABLE 1—Continued

Level	Student position
Level 5 Empirical Inference	Add to the level of sophistication by introducing empirical evidence to strengthen their theoretical argument Use appropriate, historical data to "test" the validity of an argument Use data to reach a clear conclusion or to choose between alternative theories Require at least an implicit logical framework Challenge the validity of another's empirical measure/evidence
Level 6[e] Merging Values with Analysis	They are able to move beyond objective analysis to incorporate subjective interests They may argue that although there is (positive) evidence to validate the use of a particular policy, there are other (normative) consequences that must be considered They may select a particular policy on some normative basis, from several which have positive evidence to support them.

Notes: For a posting to have achieved a given level, it is not necessary for all of the characteristics of that level to be satisfied; indeed in general, this is not the case.
[a]Level 1 is analogous to McDaniel and Lawrence's *Unilateral Descriptions*, or Nelson/Perry's *Dualism*.
[b]Level 2 is analogous to McDaniel and Lawrence's *Simplistic Alternatives*, or Ennis' *Elementary Clarification*.
[c]Level 3 is analogous to McDaniel and Lawrence's *Emergent Complexity*, Nelson/Perry's *Multiplicity*, or Ennis's *Basic Support*.
[d]Level 4 is analogous to McDaniel and Lawrence's *Broad Interpretations*, Nelson/Perry's *Contextual Relativism*, or Ennis's *Inference and Advanced Clarification*.
[e]Level 6 is analogous to Nelson/Perry's *Contextually Appropriate Decision*, Peterson and Bean's top level, or Ennis's *Strategy and Tactics*.

ous statement. They may also present new facts that modestly advance the discussion. For example, they may present an elaborate definition from the text or lecture notes. Because the source is the textbook or class notes, it is authoritative in their view. As such, they typically do not identify the source.

Genuine arguments begin to take shape at level 3, *Basic Analysis/Reasoning*. Students make a serious attempt to construct an argument or to analyze multiple arguments by appealing to simple evidence for support. These postings are reasoned assertions. The students at this stage recognize that the answer is not obvious, and consequently, an argument is required. The argument often includes more than one reason but as a listing, rather than as a logical argument building to a conclusion. The evidence may include casual empiricism or an appeal to a recognized (appropriate) authority. Often, however, no clear choice is made between alternatives. When pressed to decide on the best explanation, students will respond that all are equally valid.

The remaining three levels characterize discipline-specific thinking. At level 4, students use economic theory to make a cohesive argument. In other words, they are using *Theoretical Inference*. The postings consist of logical statements based on the discipline's accepted model/school(s) of thought that lead to a clear conclusion. Of course, even within the context of the discipline, more than one theory is likely to make logical sense. Thus, the ability to make use of *Empirical Inference* (level 5) is a crucial advance in critical thinking. Students add to

the level of sophistication by introducing empirical evidence to strengthen their theoretical argument; they examine appropriate, historical data to evaluate the validity of an argument and draw a conclusion based on these results. The key is that data are used to evaluate an argument on the basis of an accepted disciplinary theory. Although these postings will not typically include a complete exposition of the theory that is being tested, it is clear that the theoretical framework is implicit. Unlike *Basic Analysis* (level 3), this is not simply casual observation or the collection of data for descriptive purposes. Finally, at level 6 students are *Merging Values with Analysis*. They are able to move beyond objective analysis to incorporate subjective criteria. They may argue that although there is (positive) evidence to validate the use of a particular policy other (normative) consequences must be considered. Alternatively, they may select a particular policy on some normative basis from several policies that have positive evidence to support them.

WHY ELECTRONIC DISCUSSION?

Having clearly defined critical thinking in the context of economics, we now examine the advantages of various pedagogies capable of developing these skills. Instructors across the curriculum suggest a range of active learning pedagogies to promote critical thinking. By and large, these suggestions use one of two media: writing assignments or class discussion.[4] Cohen and Spencer (1993) provided an explicit model for using writing to teach critical thinking.[5] They noted that the writing process provides an essential structure by which students can generate ideas and clarify their thinking about the relationship between those ideas. They further asserted that writing can be an effective tool for teaching students a key element in critical thinking: how to develop persuasive arguments supported by logic and evidence.

By contrast, Hansen and Salemi (1990) made a compelling case for using class discussion to develop higher-order cognitive skills. The dynamic and sustained nature of an effective discussion allows for cross-fertilization of ideas and development of all participants' thinking. There can be a synergy whereby the whole is greater than the sum of the parts. They noted that "in the course of discussion students aim at producing their own answers and interpretations and at understanding and evaluating the interpretations and opinions of their colleague" (Hansen and Salemi 1990, 98).

In recent years, an increasing number of faculty have experimented with electronic discussion in their teaching.[6] Simkins (1999) suggested that Web-based tools, such as electronic discussion, can provide a different learning environment with interesting new opportunities for collaborative learning. Chizmar and Walbert (1999) used electronic discussion to help students clarify their thinking on difficult topics explained in class (think-pair-share), and to implement one-minute papers in which students identify what they see as the most important or least understood idea discussed in class that day. Vachris (1999) used electronic discussion as part of a strictly online principles course to have students comment on a reading assignment.

We think that, when used effectively, electronic discussion can provide a natural framework for teaching critical thinking to a group, capturing the best features of traditional writing assignments and in-class discussions. Electronic discussion changes the focus of the learning process, replacing the single view of the instructor with the diversity of views from different students. This diversity of views implicitly requires readers to compare and evaluate them. The asynchronous nature of electronic discussion allows participants time to reflect on what others have said and how they wish to respond.[7] Furthermore, unlike in-class discussions, every participant has the opportunity to be heard in full.[8] The public and lasting nature of the forum is likely to promote more careful commentary by the students.[9]

Another way to characterize the advantages of electronic discussion is to consider the positive spillovers that can occur in a productive discussion, where students learn from other students and faculty input is leveraged. Consider two students who, working independently, come up with different answers to the assignment. Assume that each answer is merely an opinion. We would conclude that each is at level 2 in our taxonomy (*Dualism* according to the Nelson/Perry framework). If the two students post their different views electronically, the participants in the discussion are immediately faced with a diversity of opinions. Unlike a single author, who must discover and recognize the different views on his or her own, the electronic discussion provides a structure by which that can happen almost automatically. Typically, an individual student becomes a more complex thinker only after many written assignments, after receiving the instructor's comments on the need for coherent argument and supporting evidence. In an electronic discussion, this multiplicity of opinions practically forces the student to respond in order to either support his or her assertion or to refute others'. Almost certainly, the response will be based on some type of reason or evidence. We would conclude that the participants had begun to make reasoned arguments; thus, the discussion has progressed to level 3. Even a student who enters into the discussion later can observe the standard he or she is expected to rise to to make meaningful contributions.

This "shared group memory" (Manning and Riordan 2000, 246), combined with the positive spillovers inherent in the discussions, acts to make this technique a relatively efficient way of teaching critical thinking. In typical writing assignments, instructors often find themselves repeating similar comments on multiple student papers. In an electronic discussion, however, the instructor need only make a comment once because all participants see it.

USING ELECTRONIC DISCUSSION

Since spring 1998, we have conducted more than a dozen electronic discussions in our classes, primarily in 300-level courses, using this methodology.[10] Our discussions usually are scheduled to last about two weeks. Whereas most of the discussions involved students in a single course, either intermediate macroeconomics or money and banking, several discussions included students from both courses, one at each of our two institutions. Class sizes ranged from 25 to 35 students. The software used was a threaded, Web-based discussion list. This

type of software is widely available in electronic teaching and learning environments, such as Web-CT or Blackboard's Course Info. Shareware versions are also available on the Web.

If critical thinking is to occur, students must be engaged by the assignment. In other words, students should read all or nearly all of the postings. For this engagement to occur, several things are necessary. First, the electronic discussion needs to be seen as an integral part of the course, neither optional nor extra credit. Second, the discussion should be clearly connected to the material being covered during the in-class sessions. It may also be useful to use the discussion as preliminary to a written class assignment. If so, the students should be informed of the subsequent assignment before the start of the electronic discussion.

In addition, the instructor must create a strong incentive structure for students to participate. Because the overall success of this kind of assignment depends in large part on developing a critical mass of ideas to be debated, it is important to subsidize those students who provide positive externalities. We give electronic discussion the same weight we would give a weekly or biweekly homework assignment. We use a scheme that awards credit based on the quality and the quantity of the postings. We briefly read every posting and assign two levels of credit, the lower level for simply posting and a higher level for postings that show some original thinking or genuine effort. For example, one could simply give 5 points per "typical posting" and 10 points for a particularly profound posting. In the past, we have (arbitrarily) set the assignment up to be worth a total of 30 points. We also allow for the possibility of additional credit to minimize the possibility that an engaged student will stop simply because he or she has acquired the maximum point total. Obviously, changing the relative weight of this assignment will change the size of the discussion, as students respond to the incentives. Our objective is simply to get students to make a thoughtful effort at posting comments. The more a student participates and the better their participation, the more credit they receive on the assignment. Although this scheme seems to work for us, it may not work for all instructors at all institutions. It may be necessary to tailor the incentive structure to complement the institutional characteristics.

Many faculty who use electronic discussions simply use them as a forum for students to post whatever comments and questions they wish, analogous to how the instructor might close a class session by asking if students have any questions (Bagherian and Thorngate 2000). Our approach to using electronic discussion is more structured. For each discussion, we ask students to explore and develop a consensus around an open-ended question. An example of one such assignment is shown in Appendix B. Moreover, we ask students to complete this discussion in a discrete period of time. The goal of a consensus and the limited time both serve to focus students' attention.

Perhaps more than anything else, the choice and wording of the topic and its wording is critical to the success of the electronic discussion.[11] The key is to ask students to address what Hansen and Salemi (1990) term as "interpretive questions." Such questions embody a certain degree of ambiguity that compels students to confront multiple points of view and build arguments for choosing among them. Questions like these are more likely to lead students to create arguments using

higher levels of critical thinking (see Table 1). Factual questions or questions that can be answered definitively with research are unlikely to achieve this outcome. The primary two discussion topics that we have used are given in Table 2.

Prior to the first electronic discussion in a semester, we provide instruction on both critical thinking and the mechanics of using the specific electronic discussion program. Our experience is that most undergraduates have little practice with a forum in which they have the freedom and the responsibility to create knowledge. In addition, they typically do not fully understand that to be persuasive an assertion must be developed with logic and evidence. This development requires time and discipline, which should be built into the assignment. We typically spend one class period explaining the mechanics and rules of an effective electronic discussion, as well as providing an introduction to critical thinking, based on our taxonomy.[12] To begin with, we distribute a copy of the taxonomy to the class. After terms are defined, a series of hypothetical postings are introduced for class discussion. The focus of this discussion is to get students thinking about whether the text makes logical sense, whether assertions are fully explained, and whether evidence to support it are provided. Once the students are out of class and log on to the discussion board, they are further prompted to reflect on the taxonomy within the topic that appears online. The examples in Table 2 demonstrate how the topic relates directly to our taxonomy. The reader is prompted to define terms (level 1), make use of reference material (level 3), consider tradeoffs (levels 3 and 4), present evidence (level 5), and so forth.

It is important to consider the appropriate role of the instructor as the moderator

TABLE 2
Two Electronic Discussion Topics

Electronic Discussion Topic 1
The objective of this discussion is for our class to develop a consensus view on a topic on which the experts disagree: namely, what caused the decrease in productivity growth in the U.S. economy beginning about 1973.
There are a variety of print and electronic resources available to aid you in this endeavor, including your textbook. But before you do that, it would be a good idea to define your terms. Exactly what do we mean by productivity growth? How do we measure it? What is the evidence that productivity growth has declined? As you find information with a bearing on the question, you should report it in the discussion so that other participants can check it out.
Electronic Discussion Topic 2
The objective of this discussion is for participants to develop a consensus view on a topic on which the experts disagree: namely, which concerns should the Fed take into consideration when setting policy?
The point of the discussion is to reach a conclusion, not simply to post comments. To help you do this we recommend the following: Start by trying to agree on what the goals of the Fed should be. After achieving consensus, consider the tradeoffs that exist between the various goals. Then discuss the issue of how the Fed should resolve the various tradeoffs. The first two issues should not take all that long to resolve. The last issue is much more involved. To argue your position you should use material from class, your textbook, links from the professor's syllabus Web pages, the news, economic history, and your own values. As you find information with a bearing on the question, you should report it in the discussion so that other participants can check it out.

of the discussion. To promote critical thinking, we believe that the instructor should guide students to discover insights, rather than provide insights for them. In an electronic discussion, it is the responsibility of the students to challenge each other. Although difficult for most instructors, the moderator should take particular care to avoid responding to questions, but rather should allow the students to do so.[13] Thus, the role of the moderator should be limited to maintaining focus, moving the discussion along, and periodically prompting participants to reflect on where they are and how much time remains in the discussion.[14] Often these hints by the moderator are nothing more than encouraging students to look back at the discussion topic, which serves the purpose of reminding them to think about the critical-thinking concepts. If the moderator takes too active a role, it can easily defeat the purpose of the exercise. Participants begin to expect to obtain the answers from the moderator, rather than developing answers for themselves.

The goal of a critical thinking exercise is for students to work with and evaluate viewpoints of experts to develop their own views. To efficiently achieve this goal in a short period of time (such as the length of our electronic discussions), students need to have access to these viewpoints. Whereas asking students to locate the outstanding positions on an issue is an important part of the research process, it may simply distract from the main event. Students generally would rather search for viewpoints than assess them. To that end, we provide reference materials for each discussion. Hansen (1983) argued for the use of "real books" for this purpose. The economists who write these books target them at educated lay audiences in order to promote a particular position. A good example of this type of resource is Federal Reserve publications (Peterson 2000).

Finally, we conclude the discussion with an activity designed to summarize the learning. Even productive in-class discussions can leave participants at a loss to articulate what was learned, because, unlike papers or lecture notes, there is no record of the argument. Few faculty would give a written assignment and fail to provide some feedback on the effectiveness of the exercise. Similar activities are needed after an electronic discussion. We have experimented with two types of activities. In one, we ask students to write a brief essay on their answer to the discussion question by using the arguments from the electronic discussion that they found most persuasive. The electronic record provides the raw material for their essay. If students are informed of the postdiscussion essay before the discussion, they have an incentive to take the discussion seriously. Alternatively, we ask students to identify which postings were most effective in their view and why. Almost inevitably, students identify postings that were well reasoned and supported by theoretical or empirical evidence. This reinforces the original instruction they received on critical thinking that was held before the discussion. The effect is likely to be even stronger if an additional electronic discussion is held later in the semester.

WHAT HAPPENS DURING A TYPICAL ELECTRONIC DISCUSSION?

Between spring 1998 and spring 2000, we held 10 electronic discussions. The typical discussion averaged about 200 postings and lasted for nearly 16 days (Table 3). Each student who participated posted about 6 times during the course

TABLE 3
Summary Statistics

Discussion number	Duration	Participants	Postings	Postings per student	Postings per day
1	16	N/A	168	N/A	10.50
2	18	26	63	2.42	3.50
3	9	26	168	6.46	18.67
4	27	56	320	5.71	11.85
5	18	26	177	6.81	9.83
6	17	30	264	8.80	15.53
7	10	31	156	5.03	15.60
8	21	60	346	5.77	16.48
9	12	27	253	9.37	21.08
10	11	25	106	4.24	9.64
Average	15.90	34.11	202.1	6.07	13.27
"Large" av.	21.67	48.67	310	6.76	14.62
"Small" av.	13.43	26.83	155.86	5.72	12.69

Note: Discussions 4, 6, and 8 included two classes in a joint discussion across campuses. These are the "large" discussions; whereas the "small" ones were comprised of a single section of students at one college.

of the discussion. Given the typical class size of about 30 students, these results indicate a high level of participation (90 percent or more). One obvious reason for this level of participation is the structure of our incentive system of awarding students credit. One positive outcome of this participation was a substantial amount of activity in the discussion during the typical day. If students were reading every post, they would be exposed to more than a dozen sets of facts, opinions, and arguments each day (over 90 per week) from their peers on a complex topic. It seems unlikely that even the most active class discussions could match this pace while still covering a reasonable amount of content.

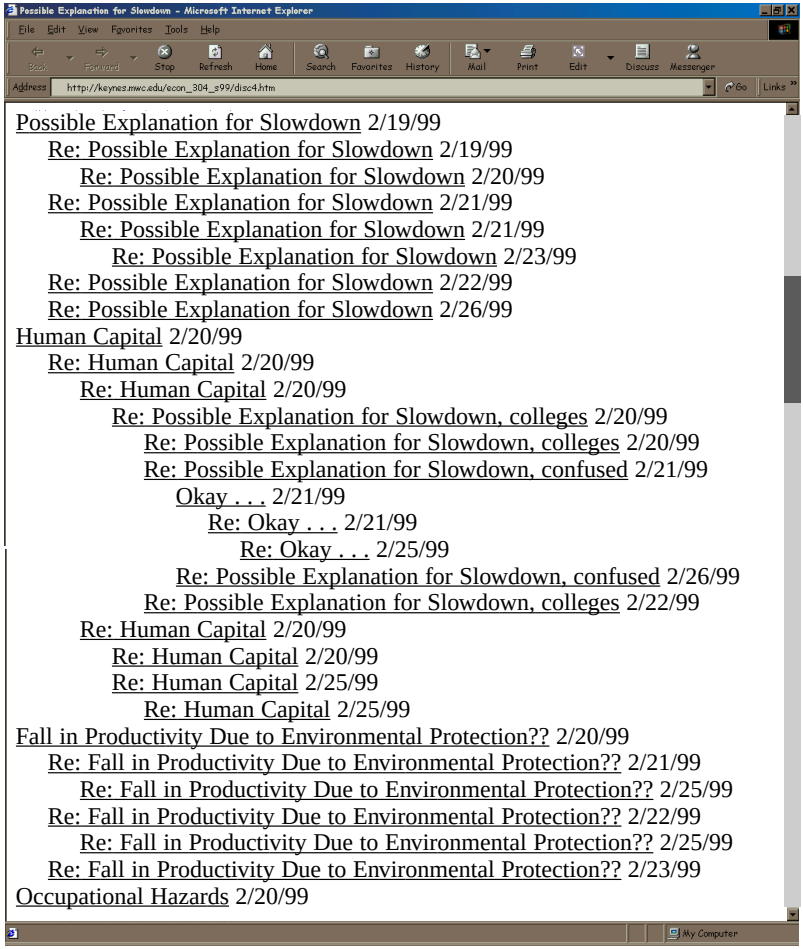
In our experience, it is not unusual for discussions to start slowly. However, as more students begin to post, the discourse becomes multifaceted. This activity is illustrated in Figure 1 with a sample panel from one discussion. The discussion evolves across multiple parallel threads, some of which may be digressions from the main topic.[15] On February 20th, for example, no fewer than four possible answers are being discussed. Participants often introduce new threads as speculations, which may or may not further the main argument (e.g., using cues like "possible explanation" or "?"). Although some threads end after the initial posting or after a few replies, one or more of these will significantly advance the frontier of the discussion. There also tend to be a few latecomers, posting four or five days after the thread has moved on to a new issue. Because of their tardiness, they contribute very little to the discussion.

Arguments in electronic discussions tend to be disjointed. By and large, discussions are not organized like a finished essay but read more like first-draft or stream-of-consciousness writing. Students often try to jump right to the conclusion rather than carefully building a case. Hansen and Salemi (1990, 98) discussed a similar phenomenon they witness during in-class discussions, observing

> [discussion] may leave some students confused, but, in our view, this is necessary for real learning to occur. Some students may not understand their colleagues' questions or responses. Others may be swayed by weak or even incorrect arguments. But along the way, students learn to judge the merits of an argument and to take responsibility for their own understanding. They become active learners and real learning occurs.

It is in this messy process that we think critical thinking occurs. Of course, this further emphasizes the need for an appropriate postdiscussion exercise that forces students to create what they perceive to be the best coherent, logical argument and separate the wheat from the chaff in the process.

FIGURE 1
View of Typical Web-Based Threaded Discussion
Topic: What Caused the Decrease in Productivity Growth in the U.S. Economy Beginning About 1973?



SUMMARY AND DIRECTIONS FOR FUTURE RESEARCH

Electronic discussion appears to be an interesting new approach to teaching critical thinking because it combines the best of writing exercises and in-class discussions. Like all pedagogies, effective electronic discussions require careful preparation. The topic is probably the most important single factor to consider. It should be a topic in which a wide range of opinions is possible, but disciplinary standards of theory and evaluation exist to assess the relative quality of arguments. To maximize the potential benefits, however, students need prior instruction on argumentation, and they need access to appropriate background materials. Following the discussion, a related, meaningful activity should be assigned so that the lessons learned are reinforced.

Our method began with an operational definition of critical thinking found in the literature, allowing us to construct a framework appropriate for teaching. The same framework should also be capable of evaluating learning outcomes. Although any attempt to formally assess whether these activities lead to higher levels of critical thinking is beyond the scope of the present study, our work suggests a number of testable hypotheses. The most interesting of these appears to be the existence of positive critical-thinking spillovers that are not present in typical writing-to-learn assignments.

APPENDIX A
Examples of the Six Critical Thinking Levels

Examples from the topic "What caused the decline in U.S. productivity growth beginning in 1973?"

Level 1—Unilateral Descriptions: Students define terms, paraphrase information, restate the question but add little or nothing new to the issue or question.

> Technological change is something that increases Total Factor Productivity. TFT is "output per generalized unit of input." The generalized unit counts capital, energy, and materials as imputs in addition to labor.

> Productivity is the ratio of a specific measure of output to a specific measure of input. Productivity measures how efficiently resources are employed—i.e—with greater productivity, more goods and services can be produced from a given amount of resources. Total factor productivity provides a measurement for disembodied technological change. Labor productivity measures the amount of output a specific worker can produce in a given time period.

Both of these authors define and identify key concepts relevant to the discussion. These are simple definitions. As such, they do not attempt to make any kind of judgment or provide any useful implication of the concepts.

Level 2—Simplistic Alternatives: Students take a side but do not explore other alternatives; they make unsupported assertions or simplistic arguments.

> Disembodied technological change does not require new machines or workers but simply a reorganization of the current capital to increase its efficiency. This can be done through research and development.

> I agree that the oil embargo in the 1970s is not the main cause of the decreased productivity rate in the past thirty years. Perhaps there should be more examination into the fact that our economy, while being technologically advanced, is moving more towards products that are intangible, i.e. a service-based economy.

The first example goes slightly beyond simple definitions by identifying some important implications that may help to further the discussion, namely that research and development is an important way to increase technological innovation. The second example is quite different. The author takes a position but does not provide a reason. In fact, it is the second sentence that advances the discussion. Like the previous example, this sentence identifies a potentially provocative avenue to be explored. In this case, the author is weakly claiming that the restructuring of industry might have something to do with the issue at hand. If he explained why he thought this, the posting would reach level 3.

Level 3—Basic Analysis/Reasoning: Students make a serious attempt to construct an argument or to analyze multiple arguments by appealing to simple evidence for support.

> In addition to the increases in oil prices, the book suggests that a reduction in expenditures on research and development and technical innovation has slowed down as a result. However, the book also states that the real price of crude oil is not much different from what it was in the 1950's and 60's so there is definitely more to it than just the increase in oil prices, as Tricia said.
>
> Productivity growth effects the growth of the real wage, and thus real income (SOL in the long-run). Gregory Mankiw states, "if the slowdown in productivity growth had not occurred, the income of the average American would today be 50% higher" (247).

Authors in both of these examples make claims. In the first example, that author relies on the authority of the textbook to support her position but also agrees with a previous posting. This is typical of many students at this level. Recognizing the validity of competing arguments, students often fail to take a stand themselves. The second posting contains a claim related to the importance of productivity, including a causal statement. Like the previous example, this author refers to a recognized authority to back his claim. However, this is not a very satisfying argument because the causality is not clearly explained in the context of economic theory.

Level 4—Theoretical Inference: Students use economic theory to make a cohesive argument.

> Energy is a complementary resource to both labor and real capital. The decrease in oil in the US during the 70's caused a great decrease in marginal productivity of labor and also capital. The demand for labor decreased with the fall in its productivity. Real wages did not fall much because workers did not expect the oil crisis to last. Given the expectations of labor and capital, people believed that the supply of labor and capital would be higher than during the shortage, consumption spending was fairly buoyant. It lead to a steep decline in the savings rate measured against current national output and income.
>
> Real GDP is reduced when the price level jumps up. This will cause the economy to move up and to the left along the aggregate demand curve. Eventually, real GDP should return to equilibrium, but the price level will be permanantly at a different level.

Although their arguments are not fully developed, it is clear that the authors are using standard economic concepts and theories in making their case. The fact that they explicitly use economic terminology shows they are beginning to think and communicate like economists. Furthermore, it is clear that by the use of these concepts (even in the absence of a detailed explanation), they expect their peers to understand their reasoning. Finally, there is a clear inference made which follows directly from their *economic* argument.

Level 5—Empirical Inference: Students add to the level of sophistication by introducing empirical evidence to strengthen their theoretical argument; they examine appropriate, historical data to evaluate the validity of an argument and draw a conclusion based upon these results.

> I think that the discussion has taken a natural progression into something that I mention at the begining fo the electronic discussion so I'd like to repeat what I said earlier and elaborate on it: When looking in Macrosolve,[16] a possible explanation for the decrease in productivity growth rate can be found when comparing the plots of output per hour (productivity)

to employment from 1930–1996. Productivity on this graph (in Macrosolve) is calculated by dividing output by the number of work hours (labor productivity). In the late 1960s, the employment rate increases, creating a steeper employment curve (an incrase in the growth rate of employment—most likely because of the baby boom and increase in minority and women participation in thy work force). In the early 1970s the growth rate of productivity declines, creating a flatter productivity curve (the basis for our discusion). From this, can the conclusion be made that the increased levels of employment equate to increased number of work hours? And that the increased number of work hours leads to a decrease in the ratio between output and work hours? Hence a decrease in productivity? One might say, "Yeah, but with increased employment, wouldn't output increase as well?" As Philip mention, the recession caused by the Oil Embargo could account for the decreased GDP. Wouldn't the decreased GDP (output) combined with the increased employment (work hours) cause a decrease in productivity (the ratio between output and work hours)? I'd like to add to this that recently (I beleive) the employment rate has fallen (possible from the baby boom generation starting to going into retirement), relative to 1973, to about an 18% participation rate. The question I want to raise is an issue of quantity versus quality in the workforce. As technology has improved, increases in capital have increased the efficiency of labor making labor more productive. I believe that the quality of labor can replace quantity in terms of productivity growth. And that the matter of returns to scale/efficiency, and economies of scale are currently affecting the productivity trends we're seeing today becasue fo this matter of quality. (sorry for spitting all this out in a sort of unorganized way, I'm in a bit of a rush. . . .) Anyone care to elaborate?

In the first sentence, the author is referring to a previous posting on which the theoretical framework was developed. As a result, it is not repeated here. We know that he has reasoned through his argument because he makes a clear choice to look at a scatter plot of output per hour and employment. Following his description of the results, he makes an inference and continues to further develop his hypothesis. Although his thinking is not consistent with a classical scientific methodology, he is not simply using the data for descriptive purposes. Rather, he is attempting to evaluate and refine an economic argument.

Level 6—Merging Values with Analysis: Students are able to move beyond objective analysis to incorporate subjective interests.

I agree that added environmental regulations have probably resulted in a decline in new tech investments since companies are having to ensure that they aren't polluting rivers or dumping smoke/chemicals into the air. It can be very expensive to equip smoke stakcs with filters and treat the chemicals that are being emptiesd in our water supply. Although I agree that this may take away from the ability of companies to invest in innovations, in the long run it is a benefit that will be visible for the rest of the planet's existence. The development of new technology may be stunted from this diversion of funds but it will not cease to move technology forward in the long run. However, the destruction of the planet's environment is a priority over a slightely lagging tech innovation and the govt is beginning to enforce this notion. The issue is defintely worth mentioning as a reason for decline in productivity though, since all the new regulations have been added after the 1970s. In my humble opinion, it is a small trade off that ensures that future generations will have a clean environment.

This posting exemplifies level 6. The author understands the economic argument that environmental regulations impose added costs to firms, which may have long-run consequences on productivity. However, he introduces a normative concern that he argues should be considered.

APPENDIX B
Macroeconomics Electronic Discussion Forum
Rules and Procedures

The objective of this discussion is for our class to develop a consensus view on a topic on which the experts disagree: namely, what caused the decrease in productivity growth in the U.S. economy beginning about 1973. A variety of print and electronic resources are available to aid you in this endeavor, including your textbook. But before you do that, it

would be a good idea to define your terms. Exactly what do we mean by productivity growth? How do we measure it? What is the evidence that productivity growth has declined? As you find information with a bearing on the question, you should report it in the discussion so that other participants can check it out.

References for Productivity Growth Discussion

1. Hall and Taylor 1993, pp. 84–93.
2. Washington Post Archives: http://www.washingtonpost.com/wp-adv/archives/front.htm
3. *Economic Report of the President*: http://w3.access.gpo.gov/eop/index.html
4. Federal Reserve publications: http://www.frbsf.org/system/fedinprint/ index.html

In the "Keyword" box, type in "productivity growth." From that list, these articles should match up with the corresponding numbers there. Then, click on "More" beside the appropriate article. This will eventually link you to the document.

(1) "Fiscal policy and productivity growth in the OECD," Cassou, Steven P. 1999.
(2) "The productivity growth slowdown: diverging trends in the manufacturing," Kozicki, Sharon 1997.
(3) "Where's the productivity growth (from the information technology)," Allen, Donald S. 1997.
(4) "Research and productivity growth: theory and evidence from patents," Kortum, Samuel 1995.
(5) "Downsizing and productivity growth: myth or reality?" Bartelsman, Eric J. 1994.
(6) "Determinants of long-run labor productivity growth: a selective," Spiegel, Mark M. 1994.
(7) "Services: a future of low productivity growth?" Schmidt, Ronald H. 1992.
(8) "Federally sponsored R&D and productivity growth," Bartelsman, Eric J. 1990.
(9) "Why has productivity growth declined? Productivity and public," Munnell, Alicia H. 1990.
(10) "Public investment and productivity growth in the Group of Seven," Aschauer, David Alan 1989.

How to Participate in the Discussion

You should post a question or comment at least twice per week while we run this discussion but hopefully you will do it more frequently. In order to post a comment or question you click on the button at the top of the homepage labeled "Submit," and enter your comment in the block labeled "Comment." To make the discussion most useful, it is good practice to always fill in the "Subject" line. Also, in order to get credit for participating, you should put your name where it says "From." When you are done with your posting, click on the button at the bottom of the screen labeled "Post Article." To read a comment, you click on it. To reply to a comment, you click on the button at the top of the screen labeled "Reply," type in your comment, and click on "Post Article."

How You Will Be Graded

You will be expected to make at least two postings per week, but as noted above, we hope you will participate more frequently. Every time you post, you will earn points, so the more you participate the higher your grade for this assignment will be. In addition, there will be a bonus for quality; that is, if you post something particularly thoughtful or original, you will earn more points than for an "ordinary" posting. The points earned on this discussion will apply to your cumulative homework grade.

NOTES

1. Whereas a number of authors propose pedagogies intended to enhance critical thinking in specific contexts, relatively few explore it in a broad sense, beginning with an operational definition and building from there. An excellent example of a study that builds from an operational definition is Thoma (1993). He summarized Nelson's variant of the Perry taxonomy for critical thinking and gave specific suggestions for how it can be effectively used to teach undergraduate economics.
2. As several authors have noted, exactly what critical thinking is and how it might be measured is generally not well specified in the literature. Yates (1978) has criticized this lack of assessment of critical thinking and other intangible but nonetheless important aspects of learning. Becker (1983) admonished researchers saying, "the fact that appropriate cognitive- and affective-domain instruments do not exist for a specific assessment task suggests that we should attempt to develop such instruments" (Becker 1983, 15).
3. Our scheme builds on Nelson's (1989) interpretation of Perry, also on McDaniel and Lawrence (1990) and Ennis (1985).
4. For example, Thoma (1993) proposed research of current economic issues, including alternative points of view, written summary, and analysis of paired readings (each indicating a different perspective), class discussions of economic issues, and analysis of issues.
5. A few articles linking writing and critical thinking have been published in economics, for example, Palmini (1996), Elliot, Meisel, and Richards (1999), and Wight (1999). Cohen and Spencer (1993), however, are the most explicit about providing a clear model for teaching critical thinking. For an excellent interdisciplinary guide to teaching critical thinking using writing, see Bean (1996).
6. Sosin (1998) and Walstad, Fender, Fletcher, and Edwards (1998) made brief mentions of electronic discussion in their surveys of Internet-augmented teaching practices. In addition, the TCH-ECON newsgroup held a thought-provoking discussion during the spring of 1999 of participants' experiences with electronic discussion.
7. Kaplan and Kies (1994) and Bean (1996) noted the benefits of giving students longer to respond to questions in class discussion.
8. Bean (1996) noted that even in a lively, well-managed in-class discussion there often is not enough "space" for any one student to develop a point thoroughly. A student is often cutoff in mid-argument. This is not a problem in electronic discussion.
9. Students appear to put more care and effort into their work when they know it will be seen by their peers. These "audience effects" have been noted by Levin and Thurston (1996), Chizmar and Walbert (1999), and Greenlaw (1999).
10. The focus in this study is our results from upper-level classes only, although we also have limited experience conducting electronic discussions at the principles level.
11. White (1985), Kaplan and Kies (1994), Hansen and Salemi (1990), and Bean (1996) all stressed this. Palmini (1996) and Chizmar and Walbert (1999) made a related point.
12. Cohen and Spencer (1993) provided instruction on how to develop a written argument in economics. More generally, Bean (1996) explained how to construct a persuasive argument in any discipline.
13. Hansen and Salemi (1990) made a similar point for successful in-class discussions.
14. Samples of instructor comments include: How does that relate to the question at hand? What have we learned so far? What needs to be worked out to complete the discussion?
15. Occasionally, there have been extensive threads that were entirely off the subject. We speculate that students may diverge from the topic because, by not addressing the issue at hand, they can minimize the risk of posting a "wrong" answer. In any case, we try to allow students the freedom to post off-the-subject to see if they will come up with something relevant. If that does not happen, the moderator can post questioning how the thread contributes to completing the assignment. This generally stops the thread.
16. Macrosolve is a computer program that accompanies Hall and Taylor's *Macroeconomics* (1993).

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