CRITICAL THINKING ISSUES- A TOOL FOR LEARNING THE SUBJECT

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Abstract

The authors have been continuously fascinated by the role of Critical Thinking Issues in improving students' learning. Critical Thinking Issues have been well recognized as a valuable tool for the assessment of educational objectives. In the Fall06 semester, Critical Thinking Issues were used as a tool for learning the subject in an environmental science course, ENVT C010. This course is a required course in the ABET accredited Engineering Technology program at Temple University. There were 16 Critical Thinking Issues in the course. The final examination contained conceptual questions, including Critical Thinking Issues on the environment. The final exam was a closed book and closed notes exam. In a survey conducted by the authors, students reported that the Critical Thinking Issues gave them several chances to study the subject in addition to paying careful attention to the lecture. This method was compared with a control group class taught in Fall 05 semester, which did not have Critical Thinking Issues.

Overall the control group had scored 64% on the average, whereas the Critical Thinking Issues group scored 75% in the course. The Critical Thinking Issues group showed 17.2% improvement over the control group. In a two-tailed t test the calculated t value was 6.5**.** The improvement of the Critical Thinking Issues group was statistically significant at an alpha value of 0.05. The result of t test confirmed that the Critical Thinking Issues are a powerful tool in learning the environmental science subject. The authors plan to extend the application of the Critical Thinking Issues concept to four other courses over the next four years.

Introduction

The students must do more than simply identify and discuss environmental problems and solutions. The first and the most important step is to know what science is and is not. Then the instructor should facilitate the process of developing critical thinking skills in the students. The instructor should present the material in a factual and unbiased style. The instructor's goal is to help the student think through the issues, not to dictate the student what to think. To meet this objective 16 critical thinking issues are listed as assignments worth of 25% of the grade. The critical thinking process is further emphasized throughout the course by organizing analytical discussions of topics, and synthesizing important themes and evaluating perspectives [1]. The Critical Thinking topics covered local, zonal, national and global environmental issues of contemporary value.

Schools, colleges, and universities are increasingly turning to the assessment of learning outcomes to evaluate the effectiveness of their programs. Critical Thinking concept is regarded as an effective tool for the assessment of educational objectives [1].

Methodology

In the Fall 06 semester, Critical Thinking Issues were used as a tool for learning the subject in an Environmental Science course, C010. The students were encouraged to make handwritten notes during the lecture. There were sixteen Critical Thinking Issues in the course. The final examination contained conceptual questions, including the Critical Thinking Issues. Except the handwritten notes, no other sources including text books, electronic versions, xerox copies were allowed to be used by the students during the examination.

In order to evaluate the improvements we need to make sure that we are comparing apples to apples only. This was obtained by replacing the twenty five percent grade of the mid-term examination in the traditional method with the same amount of grade in the Critical Thinking method. Except this, there was no difference between the two methods. The traditional lecture format and the Critical Thinking methods have seventy five percent of their grade as the same requirements. The level of difficulty for seventy five percent of the grade was the same in both courses. This was established by the design of the overall course grading formula shown in Table 1. Both the courses were taught by the same instructor. Table 2 shows the list of the 16 Critical Thinking Issues [2-9]. Appendix A describes in detail an example of a Critical Thinking issue with the corresponding Critical Thinking Questions that the students need to answer.

Students were asked to rank several activities on a scale of 1 to 5, 1 being to disagree strongly and 5 being to agree strongly. The survey consisted of ten activities ranging from students having never taken the Critical Thinking Issues before to the issues improving the student's grade on the final (Table 3).

Since the t-test is an excellent tool for comparing the means of two groups, this was used to compare the mean of Critical Thinking method over the control group [10, 11]. While conducting the statistical analysis, the effect of differential sample sizes and the minimum required number of samples have been taken care of [10, 11]. This method was compared with a control group class taught in Fall 05. A t test was conducted to determine the statistical significance of Critical Thinking method in improving the course grade.

Results and Discussion

An overwhelming majority of the students had not gone through the Critical Thinking Issues in any other courses. This was a novel concept to them. A majority of the students strongly agreed that the issues would improve their final grade, learning the issues is a time consuming process, they would recommend the concept to other courses, and they took notes during the lecture. A majority of the students strongly disagreed that the Critical Thinking Issues are useful only in engineering courses, extensive reading of the text was not required because of hand written notes, read the text and prepared notes ahead of lecture, did second round reading after the lecture, and integrated and organized the notes.

Learning the Critical Thinking Issues is a time consuming process because students had to conduct research, make notes and prepare more than the traditional method. The concept can be used in any course as it provides a thorough learning experience for the student. In the course, the control group had scored 64% on the average, whereas the Critical Thinking group scored 75%. The control group had 12 respondents while the Critical Thinking Group had 11 students. The Critical Thinking group showed 17.2% improvement over the control group. The calculated t-value was 6.5. The improvement of the Critical Thinking Issues group was statistically significant at an alpha value of 0.05. The result of t test confirmed that the Critical Thinking Issues are a powerful tool in learning the Environmental Science subject. The authors plan to extend the application of the concept of Critical Thinking Issues to other courses.

Conclusion

In the survey conducted by the authors, students reported that the issues gave them several chances to study the subject in addition to paying careful attention to the lecture. They indicated that they got the opportunities for learning the subject before the lecture, after the lecture and just before the test. The result of the t test confirmed that the issues are a powerful tool in learning the Environmental Science subject.

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Table 1. Grading Formulas

	Control group (Percent)	Pretest group (Percent)
1. Assignments	25	25
2. Attendance and class participation	10	10
3. Mid-term examination	25	0
4.Final Examination	40	40
5. Critical Thinking Issues		25
Total	100	100

Table 2. List of Critical Thinking Issues

1. How many people can earth support?
2. How can we evaluate constructed ecosystems?
3. Will there be enough water to produce food for a growing population?
4. Is Lead in the urban environment contributing to antisocial behavior?
5. How should New Orleans be rebuilt?
6. Is there enough energy to go around?
7. Should the gasoline tax be raised?
8. How can we evaluate alternate energy sources?
9. What is the future of nuclear energy?
10. How can polluted waters be restored?
11. Are airplanes adequately ventilated?
12. Human-made chemicals and the Ozone Hole: Why was there controversy?
13. Will mining with microbes help the environment?
14. US Fisheries: How can they be made sustainable?
15. How can urban sprawl be controlled?
16. Can we make recycling a financially viable industry?

Table 3. Student Survey on the Critical Thinking Issues

Please rank the following activities on a scale of 1(strongly disagree) – 5(strongly agree).

S.No.	Activity	Ranking	Relative Ranking
1	Never took Critical Thinking Issues in other courses	4.8	1
2	Read the text and prepared notes ahead of the lecture on the Critical Thinking Issues	2.1	8
3	Took additional notes during the lecture	4.3	3
4	Did the second-round reading after the lecture and integrated and organized the notes	1.9	9
5	My notes helped me score higher on the tests	3.8	6
6	Extensive reading of the text was not required because of hand-written notes	2.4	7
7	This is a time consuming process	4.0	5
8	Critical Thinking Issues will improve my grade on the final	4.2	4
9	Critical Thinking Issues are useful only in engineering courses	1.3	10
10	Will recommend Critical Thinking Issue concept for other courses	4.4	2

Comments:

Appendix 1: Example of a Critical Thinking Issue with Critical Thinking Questions[1]

How Can We Evaluate Alternative Energy Sources?

The world is moving into a new era, one of transition from almost total dependence on fossil fuels to greater use of alternative renewable sources of energy. Although each of the alternatives offers a way out of the energy dilemma created by population growth and technological development, each has advantages and disadvantages. How can we evaluate the alternatives and select the right mix of energy sources for the coming decades? We can begin by comparing them on the basis of those characteristics most important to us: cost, jobs lost or gained, environmental impact, and potential for supplying energy.

Critical Thinking Questions

1. Using what you have learned about alternative energy in this chapter and elsewhere, evaluate the environmental impacts of the energy sources listed in the accompanying table. Complete the last column of the table. You may wish to subdivide the column into advantages and disadvantages.

2. Using the numbers 1–10, where 10 represents the best and 1 the worst, assign a rating to each value in the table. For example, in the column for carbon reduction, you might assign a rating of 10 to wind because it results in 100% reduction of carbon emissions. Solar thermal energy would then receive a rating of 8.4. In rating environmental impact, you will have to use your judgment in assigning numerical values.

3. One way to evaluate the various alternatives would be to add up the rating scores for each energy source and see which ones received the highest score. However, you may feel that some of the characteristics are more important than others and therefore should be weighted more heavily. Assign a weight to each column of the table, taking into consideration the importance you believe each should have in decision making. For example, if you believe that costs are more important than land used, you will assign a higher value to costs. In order to be able to compare your evaluation with those of your classmates, use decimal fractions for the weights, such as 0.2. The total should add up to 1.0.

4. Now, for each energy source, multiply its rating in each column by the weight you have assigned to the column. What is the total weighted score for each energy source? What are the sources in order of score, from highest to lowest?

5. Based on this analysis, what policy and research recommendations would you make to the U.S. government concerning alternative sources of energy?

Energy Source	U.S. Recoverable Resource[a] (exajoule/yr)	Costs in 1998 Cents[b] (per KWh) 1988	2000	Land Use[c] (m^2/GWh for 30 years)	Carbon Reduction (%)	Carbon Avoidance Cost[d] ($/ton)	Number of Jobs[e] (per thousand GWh/yr)	Environmental Impact
Wind	10–40	8	5	1,355	100	95	542	
Geothermal	Small	4	4	404	99	110	112	
Photovoltaic	35	30	10	3,237	100	819	—	
Solar thermal	65	8	6	3,561	84	180	248	
Biomass	13–26	5	NA	—	100[f]	125	—	
Combined-cycle coal	—	6[g]	—	3,642	10	954	116	
Nuclear	—	15[h]	—	—	86	535	100	

[a] *Recoverable resource* is a measure of how much of the energy can be captured or exploited. From M. Brower, *Cool Energy* (Washington, D.C.: Union of Concerned Scientists, 1990), p. 19.

[b] L. R. Brown, C. Flavin, and S. Postel, *Saving the Planet* (New York: Norton, 1991), p. 27.

[c] Ibid., p. 60.

[d] Based on comparison with existing coal-fired plants. From C. Flavin, "Slowing Global Warming," in *State of the World* (New York: W.W. Norton, 1990), p. 27.

[e] Brown et al., p. 62.

[f] Assumes that the amount of carbon dioxide released in combustion will be consumed by replanted vegetation.

[g] C. Flavin, "Building a Bridge to a Sustainable Future," in *State of the World* (New York: Norton, 1992), p. 35.

[h] A. K. Reddy and J. Goldenberg, "Energy for the Developing World," *Scientific American* 263 (3)(1990):116.