Overlaying Critical Thinking to Information Systems and System Engineering Courses

John W. Fendrich jwfendr@ilstu.edu
Applied Computer Science Department
Illinois State University
Normal, IL 61790-5150 USA

Abstract

This paper reports on the efforts to overlay critical thinking to the courses in computer science and computer information systems in college courses taught by the author during Summer Session II 1999, Fall Semester 1999, January Interim 2000, and into the Spring Semester 2000, Summer Session II 2000. Activities for doing this are discussed. These include integrating critical thinking with product-based learning (PBL), team-based learning (TBL), and student management teams (SMT). These ideas of teaching and learning are discussed with the objective of communicating with others, enabling debate, encouraging alternative ways, motivating others to do more.

Keywords: Team-Based Learning, Student Management Teams, Product-Based Learning, Critical Thinking, Moore's Law, Real-World Projects

1. INTRODUCTION

What is needed in training and education is always changing. The author has observed this through a significant period of trying to teach. It is a daunting challenge to keep what is taught consistent with what is needed. This challenge is increasing without end. As in system development, the way is often to do what one can, rather than to break new ground in attempting to do what is needed. Thinking, finding what is needed, making choices, and the building the products and services to meet those identified needs in short time frames with accompanying successes and failures are common system engineering experiences. This is existentialism exhibited in system development. Students, who take courses, discussed in this paper, report feelings of existentialism. Such existential approaches of doing what is needed are not easy. They are full of risks.

It has been asserted that work, serendipitous ways, domino effects of innovation, capabilities, productions, concepts are happening more often at amazing rates, which can be described by exponential transformations. Moreover, it has been observed that the near-linear pace of change early in such exponential transformations turns to an accelerating rate as more of the curve of such exponential transformations is traversed or experienced. There is stress in making the orderly, disciplined, systematic, methodical, process-oriented ways, which work during periods of near-linear acceleration, continue to work. More existential ways, accompanied by very capable thinking and communication, are needed to avoid more chaos and to respond to needs. Such existential ways, accompanied by very capable thinking structures and intellectual standards, together with communication of such thinking and control, can react to and control rapidly changing technological capabilities, which, themselves, follow exponential transformations. This is exponential growth spawning more exponential growth.

The paper reports on the author's recent attempts at preparing people for such environments. The work reported in the paper extends work done with incorporating team-based learning, product-based learning, and student management teams into system engineering learning and information systems learning.

The author has used team-based learning (TBL) for two decades in his teaching. He has used student management teams (SMT) for nearly a decade. He has attempted real-world projects in courses for at least eight years. The idea of product-based learning (PBL) has been incorporated into his courses for a few years. The more recent attempts, reported here, overlay critical thinking into this structure. The author's experience has been that such training/education prepares human resources to get through existential system development environments. Problem solving, in response to accelerating change, occurring when the applications constitute an environment rampant with exponential growth, needs people prepared for doing critical thinking within the intense system development environments that such change engenders.

2. REVIEW OF PROBLEM-BASED LEARNING (PBL),TEAM BASED LEARNING (TBL), STUDENT MANAGEMENT TEAMS (SMT)

Some of the experiences traversed in the near-linear rates of change in the early phases of exponential transformations of development environment and application deployment have motivated attempts, successes and failures of team-based learning, product-based learning, and the participatory learning experiences of student management teams. The use of such learning methods and motivations contrast with competition-based, test taking, doing-what-instructors-expect methods and motivations.

Team-based learning emphasizes cooperative, supportive, and collaborative ways of task accomplishments and achievement, as opposed to strictly competitive, self-assertive, individual, and independent ways of accomplishing tasks and achievement. There is controversy here. It is not either–or.

Product-based learning emphasizes the production of products, useful real-world products, with the learning of concepts, methods, and techniques of product development and production as a learning by-product. It is learn-by-doing, rather than a methodical breakdown and analysis of the theories and concepts, and then a later choosing from a vast store in an eclectic manner, when needed. This product-based learning methodology too is controversial. Again, it is not either-or, or in an absolute sense. It is more existentialism.

In the author's experience in presenting courses, student management teams exemplify participating in learning. It includes the idea of students in training/education environments taking the responsibility for their learning by managing and controlling the activities that make up their learning. When compared to the long history of relying on a sage or professor, who undertakes all the responsibility of learning, this too is controversial.

Experiences with TBL, PBL, and SMT have been reported by the author and some other sources. This paper reports on the extension of these methods and techniques by the overlaying of critical thinking onto courses that include TBL, PBL, and SMT.

3. INTRODUCTION TO CRITICAL THINKING AND ITS RELATION TO SYSTEM ENGINEERING WORK AND INFORMATION SYSTEMS WORK

Critical thinking is Meta thinking. It is thinking about thinking. Thought, as expressed in forms of communication, is analyzed. This is done by analyzing the structure of thought (purpose, point-of-view, assumptions, implications and consequences, use of data, facts and experiences, inferences, concepts and theories, attempts to answer a question or solve a problem), and by applying intellectual standards (clarity, accuracy, precision, relevance, depth, breadth, logic, significance) to the thought. There are more extensive expositions of critical thinking and in-depth communications on critical thinking. But the essence of critical thinking is to analyze thinking (in whatever form it may take) by focusing on its structure and evaluating the thinking using intellectual standards criteria.

Critical thinking can be a human skill and tool to assess the thinking within the existential product development and system development in times of accelerating change. Such assessment skills can be used to utilize, review, and improve the products of system development. It is a skill applied in team work and product production work in stressed development environments. Getting people accomplished and skilled at critical thinking is an essential education task. This paper reports on the author's attempt to overlay critical thinking to system engineering education and information system education through his recent course offerings in a university. It is not an end-all way. Others can think of other ways or debate the controversial parts and implications of what is reported here. More can be done. There are more alternatives (points of view).

4. REPORT ON THE OVERLAY OF CRITICAL THINKING TO RECENT COURSES IN SOFTWARE ENGINEERING, NETWORK ENGINEERING, SYSTEM ANALYSIS AND DESIGN, SYSTEM SPECIFICATION AND DEVELOPMENT, FILE ORGANIZATION ANDMANAGEMENT, COMPUTER LAW, COMPUTING SERVICES MANAGEMENT, SYSTEM ENGINEERING MANAGEMENT, AND INFORMATION SYSTEM MANAGEMENT

Critical thinking has been overlaid on courses CS 615, Software Engineering I, CS 643, Data Communications and Distributed Computing Architecture, CIS 608, System Specification and Development, CS 403, System Analysis and Design, CIS 607, File Organization and Management, CIS 571, Computer Law, CIS 572, Computing Services Management. This was done in Summer Session II 1999 for CS 615 and CS 643, and in Fall Semester 1999, in CIS 608, CIS 607, and CS 403, in January 2000 Interim in CIS 571, and in Spring Semester 2000 in CS 403, CIS 571, CIS 572 courses. Most recently critical thinking has been overlaid in Summer Session II 2000 in CS 615 and CIS 607. This was overlaid to TBL, PBL, and SMT project activity instances in all those courses. Detailed TBL, PBL, and SMT instances have been reported in other conferences and symposia.

The critical thinking overlay, reported here, included these course activities.

- Instruction on critical thinking by means of coverage of structure of thought. Critical thinking instruction by covering the application of intellectual standards to thought. This is done via lecture and discussion in a session of about fifty minutes.
- A Socratic method session and activity to introduce the idea that one can not analyze the thoughts of others using critical thinking unless one listens to others and can articulate what others have expressed accurately.
- Three review activities to analyze the thoughts of others communicated in writing using critical thinking. This includes reviewing the course information sheet (Syllabus) for the course, along with reviewing up to three textbooks chosen for a course. Then a written review is produced based on the critical thinking analysis. This provides practice in critical thinking. There is opportunity here for practice in the ideas communicated on the structure of thought and the application of intellectual standards to thought. Opportunity for additional critical thinking practice is presented by two-person reviews of the reviews of the course information sheet and textbook reviews, with corrections being made based on the two-person reviews.
- A succession of individual research and investigation assignments to review, again using critical thinking analysis, Internet sites specializing in subjects included within the domain of the course or related to the subject matter of the course. Then individuals make presentations, based on those reviews, within class meetings.
- Encouraging people to practice structure of thought and the evaluation of thought through the application of intellectual standards in the thinking that occurs in PBL, SMT, and TBL projects within courses. Making opportunities to do this sort of thinking about thinking in the process of carrying out PBL, SMT, TBL in the courses of Summer 1999, Fall 1999, January 2000, Spring 2000, and Summer Session II 2000, was essential.
- Encouraging people participating in a course to give in-progress presentations, reports, and reviews of documentation, prototypes, management activities and other products to the class associated with a course. This being done in the various real-world, topics, and SMT projects in a course.
- Encouraging people, who were participating in a course, to try and to apply structure-of-thought and intellectual standards to evaluate intermediate process capabilities and intermediate product quality. Encourage people to thereby gain experience and practice in decision making in the student management of team projects. Encourage people to get the understanding of

the decision making that goes on in project direction and control that critical thinking enables

5. DISCUSSION OF THE RESULTS

The author has observed these results in his attempts to overlay critical thinking into computer science and information systems courses in the Summer Session II, 1999, Fall, 1999, January 2000, Spring, 2000, and Summer Session II 2000.

1. Students learn what critical thinking is by practicing it (learning by doing).
2. Instructor and students gain experience in analyzing the thinking of others in the work done on PBL, TBL, and SMT activities in the course.
3. Students get practice in applying critical thinking to the thinking done in working out PBL, TBL. SMT projects. This is even more valuable if the course projects have real-world characteristics or experiences incorporated in them or when such experiences just happen in the course of the projects.
4. Everyone learns that critical thinking is not natural. For instance, just because one has a doctor of philosophy degree does not mean her or his thoughts automatically evaluate well in critical thinking analysis.
5. Critical thinking can be useful in evaluation of system engineering and information systems proposals, documentation, products, policies, procedures, standards, for continuous improvement of products within PBL, SMT, TBL courses.
6. Realization that there is not much thought that scores well with critical thinking analysis in information systems work and activities. For example, systems often are built within PBL, SMT, and TBL courses from thought adhering to a technology point of view.
7. The experience enables one to improve one's own thinking by cycling through the structure of thought and the evaluation of that thought by applying intellectual standards. This enables people with this experience to choose to be a better, more effective, more efficient system engineering and information systems worker.
8. The overlaying of critical thinking is useful in learning. It makes learning more efficient by providing the opportunity for discarding, or better yet improving, thoughts that do not show sufficient structure or meet standards. It also aids understanding of the thinking of others, just by analyzing that thinking according to the structure and conformance to intellectual standards

6. SUMMARY

This paper introduced a need to evaluate information system education thinking in the face of the accelerated changes to systems and needs for systems in times that are influenced by exponential growth. The need is that of being able to have a basis to educate and train with product production experiences that are existential in character. The paper reports on the author's attempts at some different education and training strategies to meet such needs. This is a report on the overlaying of critical thinking strategies on the strategies of TBL, PBL, and SMT in teaching and learning systems engineering and information systems. The paper reports on activities incorporated into information systems and systems engineering courses to prepare students. It is done in the spirit of an introduction to the thinking of the author on information system training and education. It is done in the spirit of encouraging debate or encouraging others to carry on this effort. There are more experiences that need to be reported. For instance the application of critical thinking, PBL, TBL, SMT to lower division courses in computer science and information systems needs experiences carried out and reported on.

7. REFERENCES

Annual Lilly Conference on College Teaching, Marcum Conference Center, Miami University, Oxford, Ohio, November 1991. Ideas on student management teams introduced to the author there.

Critical Thinking Workshop, June 26-29, 1999, Chicago, Illinois, Foundation for Critical Thinking.

Denning, Peter, 1999, Talking Back to the Machine Computers and Human Aspiration, , Editor, see especially, articles by Peter Denning, James Burke, Gordon Bell, Carver Mead, Joel Birnbaum, Bran Ferren, Bruce Sterling, Copernicus Springer-Verlag,.

Fendrich, John W., Summer Session II 1999CS 615 and CS 643 Course Handouts, Computer Science and Information Systems Department, Bradley University, Peoria, IL 61625.

Fendrich, John W., Fall Semester 1999, CS 403, CIS 607, CIS 608 Course Handouts, Computer Science and Information Systems

Department, Bradley University, Peoria, IL 61625.

Fendrich, John W., January Interim 2000, CIS 571 Course Handouts, Computer Science and Information Systems Department, Bradley University, Peoria, IL 61625.

Fendrich, John W., Spring Semester 2000, CS 403, CIS 571, CIS 572 Course Handouts, Computer Science and Information Systems Department, Bradley University, Peoria, IL, 61625,.

Fendrich, John W., November, 1998, "Case Studies in System Quality Assurance," Proceedings of the Las Vegas, Nevada IASTED Conference on Software Engineering, pages 364-370, ACTA Press.

Fendrich, John W., , August 1999, "A Report on Using Experiential Learning To Deliver System Engineering Training/Instruction to Computer Science and Computer Information Systems Students," 17th Annual International Conference of the Association of Management and the International Association of Management 1999 Computer Science Proceedings, pages 347-352, Maxmilian Press Publishers.

Fendrich, John W., Christos Nikolopoulos, October 1999, "An Interdisciplinary Approach to Information Systems Intelligent System Curriculum," ISECON'99, Rosemont, Illinois.

Fendrich, J., C. Nikolopoulos, "Application of Mobile Autonomous Robots to Artificial Intelligence and Information Systems Curricula," Real-Time Systems Education III, pages 72-76, IEEE Computer Society, 1998.

http://www.criticalthinking.org/University/default.html

http://www.cs.tamu.edu/people/jdurbin/texts/existentialism.def.html.

National Technological University, November 15, 1997, "A Collaborative Experience in Global Product-Based Learning", Videotape Program, http://www.ntu.edu.

NSF Summer Institute, Summer 1992, Bringing the Industry View of Software Engineering to the Classroom, Indianapolis, Indiana.

Nikolopoulos, Christos, John Fendrich, October 1999, "Robotics and intelligent agents as a theme in AI Education," ISECON'99, Rosemont, Illinois,

Ray, Josh, September 1, 1999, Individual presentation in class, CS 403, System Analysis and Design, Bradley University Computer Science and Information Systems Department, Peoria, IL 61625.

SUNERGY Internet site, http://www.sun.com/sunergy.

.