Problem-based Learning in a Multi-electronic Media Classroom

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Abstract

This paper describes the study being performed in the Chemical Engineering Department at Lamar University to integrate best practice pedagogy with computer-aided modeling and simulation into a problem-based learning (PBL) program. The program requires a multi-electronic media classroom that has been set up and will be discussed in terms of the pedagogical objectives of PBL. This setup in the classroom frees the students to concentrate on the information being discussed in class. A path-finder course is being developed to promote the PBL in the chemical engineering curriculum.

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I. Introduction

This paper is the result of an adaptation and implementation proposal that has been funded under the Course, Curriculum and Laboratory Improvement Program of the National Science Foundation [1]. It involves the innovative use and extension of problem-based learning (PBL) in Chemical Engineering education at Lamar University. The project focuses on the integration of computer-aided modeling and simulation into the courses and curriculum in both undergraduate and graduate education. It starts with the development of a new course, Computer-Aided Modeling and Simulation (CAMS) for the PBL pedagogical preparation. The CAMS serves as a path-finder course for several chemical engineering majoring courses in the curriculum. It ends at a senior last semester course, Advanced Analysis where the PBL pedagogy is fully implemented. We have presented parts of our project in three engineering education conferences [2–4]. This paper describes briefly our experiences in undergraduate teaching development.

II. Problem-based Learning

Recently, PBL is undergoing a strong push in engineering education [5] and precedents exist for the incorporation of computer-aided modeling and simulation into the process [6]. Problem-based learning (PBL) is broadly defined as an educational approach to structuring curriculum and courses that involves facing students with problems that provide an incentive to learning [7]. It generally has the following attributes [8]:

- Student centered.
- Small student groups.
- Teachers are facilitators or guides.
- Problems form the focus and stimulus for learning.
- Problems are a vehicle for the development of problem-solving skills.
- New information is related through self-directed learning.

III. Classroom

University classroom design has been traditionally conservative with the legacy of the traditional science based classroom as its base. However, problem-based learning has demanded more flexible classroom designs. Adding electronic based multi-media and computer-aided learning methods has raised additional demands on the classroom design architecture. Traditional arrangements of computer laboratories and classrooms do not meet the demands of a problem-based learning pedagogy.

A. CCLI Prototype Classroom

The NSF-CCLI project has been using a small prototype computer based classroom to test the principals of PBL and computer-aided learning. Seven computers in the classroom are connected by a CISCO Aironet 350 Wireless Networking System. The main server for the instructor is a Gateway E-4600 SE with Windows 2000 Server. The students have 6 Client Computers - Gateway E-1600 SE with Windows 2000 Professional. The instructor station and three student computers are connected to four electronic white boards of 4’x 6’. In addition, there is a Toshiba TPL 671 LCD Projector and a Webcam.

1) *Electronic White Board*: The electronic white boards allow the instructor and PBL groups to: save everything written or drawn on the board to PC; record what’s written in 4 colors; send e-mails, or posts notes directly to the department Web site to share with colleagues world-wide; support real time teleconferencing with remote participants; and use Projection Screen Support to make the white board a touch-sensitive projection screen by connecting to PC and LCD Projector.

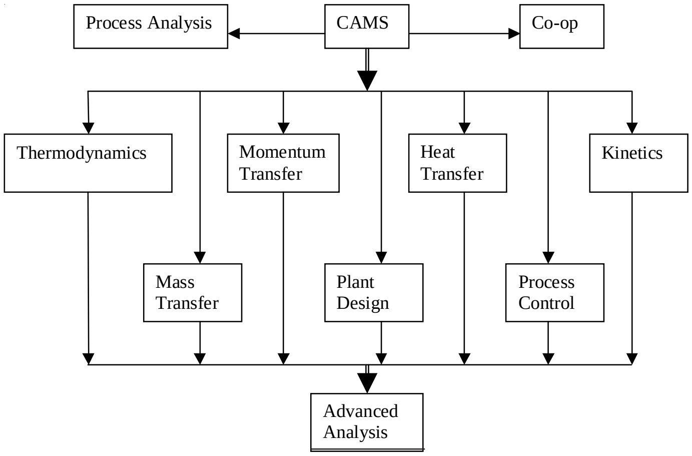
2) *Multimedia Electronic Projector with Overhead Camera*: This projector allows Powerpoint material, transparencies, and textbook materials to be projected. This makes an easy transition for instructors who have materials on transparencies and/or still depend on textbook use in the classroom.

3) *WebCam:* The WebCam is used for videoconferences with individual groups allowing the instructor to work with PBL groups from remote locations. It also allows material to be digitized and transmitted to the class by e-mail or other digital recording media.

IV. Curriculum for PBL Pedagogy

A. Computer-Aided Modeling and Simulation (CAMS) – A Path-finder Course

The NSF CCLI-A&I project has initiated a prototype course to integrate problem-based learning (PBL) pedagogy into the chemical engineering curriculum with an implementation of computer-aided modeling and simulation packages. It starts with a new course, CAMS (Computer-Aided Modeling and Simulation), in the sophomore level and concludes at a senior course of Advanced Analysis. The course structure can be seen from the chart below.



In the CAMS class, the sophomore students are introduced to two types of computer packages: mathematical packages (MathCad and POLYMATH) and simulation packages (Aspen and ProII). During the first six weeks of class, the students use the mathematical packages to solve math problems that typically arise in upper-level chemical engineering classes, including regression (both linear and nonlinear), nonlinear equations, and systems of ordinary differential equations. The remainder of the semester is devoted to familiarizing the students with the simulation packages. Since these sophomore students have not yet had any chemical engineering courses (except the material and energy balance class, which they take concurrently), some time is spent describing the theory behind such common unit operations as flash drums, heat exchangers, chemical reactors, distillation columns, etc., as well as the theory behind each package's solution algorithm. Of course, many of the details are left to later upper-level classes, after the students have been introduced to the required fundamental theory. However, problems in several junior and senior courses are given in this class and solved by computer packages.

To start a Computer-Aided Modeling and Simulation teaching at a stage as early as sophomore is quite new in the chemical engineering curriculum. Nevertheless, after two years experimenting, the NSF-CCLI implementation project finds that the advantages are quite obvious.

The first advantage is to help the students in co-op program and in Process Analysis (Material and Energy Balance). Most of our co-op students use one of the Computer-Aided Modeling and Simulation packages (such as ASPEN, PROII, and HYSYS) during the co-op time period. CAMS prepares them early enough that they will be able to move into the working situation quickly to solve a practical problem in industry. When the co-op students come back to school to learn the fundamental principles in junior/senior engineering basic courses, they already have this "problem-based learning" pedagogical mind-set. This helps to pave the way of "problem-based learning" pedagogy in chemical engineering curriculum.

The NSF-CCLI implementation project has found that the co-op students can learn the fundamental principles more effectively than the non-co-op students. This could be a difference between the learning pedagogies of science and engineering education. In other words, the engineering students feel the need to learn fundamental principles in order to solve problems.

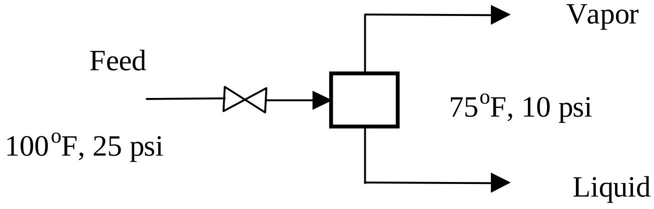
The other advantage for the CAMS is to prepare the students for the chemical engineering sophomore (Process Analysis), junior (Thermodynamics, Momentum Transfer, Heat Transfer, and Kinetics) and senior (Mass Transfer, Plant Design, and Process Control) courses in problem-based learning with an implementation of computer-aided modeling and simulation. CAMS teaches the students to do a process simulation for the units of Mixers, Separators, Heat Exchangers, Columns, Reactors, and Pressure Changers. These units are the applications of Process Analysis, Momentum Transfer, Heat Transfer, Mass Transfer, and Kinetics. Besides, the selection of the thermodynamic models prepares the students to learn a non-ideal mixture of chemical compounds that will be studied in Thermodynamics. Thus, CAMS serves as a path-finder course in the chemical engineering curriculum.

B. Advanced Analysis

Finally, in a last semester senior course, Advanced Analysis, the CCLI laboratory will be used fully to implement the CAMS and the problem-based learning pedagogy. In the Advanced Analysis, chemical engineering problems are given to the students at least one week ahead for the students to study. In the class students have to use the fundamental principles learned from the courses (shown in the above chart) to set up the system equations or the inputs for the CAMS packages. The instructor may initiate the questions and when the students answer the questions the others may challenge those answers. The instructor may give minimum necessary corrections in order to encourage the discussion. Through this problem-based learning pedagogy, students can concentrate more than a traditional teaching method because of the participation.

To fully use the PBL pedagogy, a description of the problem must be distributed to the students days or even one week before the class discussion. This gives time for the students to understand the problem, search for references, and prepare for the class discussion. Examples are given below:

1) *Flash vaporization:* The problem given in the class is an equilibrium flash vaporization. A feed stream flowing at 1000 lb/hr contains an equimolar mixture of n-butane, n-pentane, n-hexane, and n-heptane at 100°F, 25 psi. The feed enters a flash drum maintained at 75°F and 10 psi. What is the flow rate and composition of the vapor and liquid streams leaving the flash drum?



What students can discuss from this problem are (1) equilibrium versus non-equilibrium flash vaporization, (2) isotherm versus adiabatic flash vaporization, and (3) pre-heat versus reduce pressure flash vaporization. Students are encouraged to participate in the discussion and modeling of the system.

Because of the electronic board, the students do not have to worry about taking notes. Instead, they can concentrate on the discussion of the modeling process. The instructor gives only guidance but not the "solution." Both sides of an assumption should be explored and discussed, and a reasonable assumption can be recognized but not assigned. Because of participation, the students have a better understanding of the problem than the traditional one-way lecture.

To solve the system equations, we show briefly the algorithm and an old computer program written in BASIC to obtain the input and output, converged solution. Then, we ask the students to use ASPEN (or PROII) to work on the same problem. Although they have learned the package in the sophomore course, CAMS, now, they can appreciate the simulation package. But, this is not the end. The class should take advantage to explore the effects of process variables. The instructor will enjoy the presentation of the results. Be prepared for the discussion.

The students can present their results through a computer network with the LCD projector. Now, again, the interpretation is open to discussion. For this example, the effects are simple: more lighter compounds will be vaporized if low drum pressure or a feed pre-heater is used. For other more complicated system, the discussion of the results is quite involved. Most of the students find that it is very helpful to understand the system behavior through the discussion of the result. This part is called the interpretation of the results.

2) *Safety Analysis*: Another part of the Advanced Analysis is safety case study. The class was separated into three groups for the study of the following three cases: Piper Alpha – Spiral to Disaster; Phillips 66 Company Explosion and Fire at Pasadena, Texas; and Methacrylic Acid, Tankcar Explosion and Methods of Safety Handling.

All these three cases are from the Safety and Chemical Engineering Education (SAChE) Division in the American Institute of Chemical Engineers (AIChE).

The materials including video and CD were distributed to the groups one week before the group final presentation. The students watched the video/CD, discussed the events occurred, and then analyzed the safety considerations. The students used the electronic board for group discussion. The instructor monitored the group discussion from the instructor's station but did not interrupt their discussion. All the group discussion material is saved into the computer without typing. The students are totally free their mind from the typing or note taking so that their group discussion is very involved. We find this type of "problem-based" and "student-centered" discussion and learning are very effective. Every student was challenged to participate and contribute to the problem solving.

V. Conclusion

A change from instructor-centered to student-centered, computer-aided PBL learning in higher education poses challenges for administrators, educators, students and classroom designers. Computer based PBL courses must be carefully designed to meet the pedagogical objectives. In the case of computer-aided PBL, the course material and the modern electronic classroom are essential for optimization of the PBL process.

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References

[1] National Science Foundation: #9981152 titled “Integrating Best Practice Pedagogy with Computer-Aided Modeling and Simulation to Improve Undergraduate Chemical Engineering Education.”

[2] Li, Kuyen, Carl L. Yaws, Daniel Chen, John L. Gossage, T. C. Ho, and David L. Cocke, “Integrating best practice pedagogy with computer-aided modeling and simulation to improve undergraduate chemical engineering education”, *Proceedings of American Society of Engineering Education and Exposition, Albuquerque, June 2001*, American Society of Engineering Education, 1818 Str. NW Washington, D. C., (2001).

[3] Li, Kuyen, Carl L. Yaws, Daniel H. Chen, John L. Gossage, T. C. Ho, and David L. Cocke, “Integrating Best Practice Pedagogy with Computer-aided Modeling and Simulation to Improve Undergraduate Chemical Engineering Education”, *Proceedings of the International Conference on Engineering Education, ICEE 2000*, Taipei, Taiwan, ROC, August 14-16, 2000.

[3] Li, Kuyen, Carl L. Yaws, Daniel H. Chen, John L. Gossage, T. C. Ho, and David L. Cocke, “Integrating Best Practice Pedagogy with Computer-aided Modeling and Simulation to Improve Undergraduate Chemical Engineering Education”, *Proceedings of the International Conference on Engineering Education, ICEE 2000*, Taipei, Taiwan, ROC, August 14-16, 2000.

[4] Cocke, D. L., Kuyen Li, Kadir Dede, and Emrah Alici, “Multi-Electronic Media Classroom for Computer-Aided Problem-Based Learning” Proceedings of the ASEE Gulf-Southwest Annual Conference, The University of Louisiana at Lafayette, March 20-22, 2002, IIIA6.

[5] Wilkerson, L. and Wim H., Gijselaers, 1996, *ASEE PRISM*.

[6] Corte, E. D., 1992, *Computer-based Learning Environments and Problem Solving*, NATO ASI Series F, Computer and System Sciences, Vol. 84.

[7] Boud, D. and G. Feletti, ed. 1998, “The Challenges of Problem-Based Learning,” Kogan Page, London.

[8] Barrows, Howard S. (1996). Problem-based learning in medicine and beyond: a brief overview. In Wilkerson, L. and W. H. Gijselaers. (Eds*). Bringing Problem- Based Higher Education: Theory and Practice: New Directions for Teaching and Learning No. 8* (pp.5-6). San Fransisco: Jossey-Bass.