An Innovative Approach in Teaching Professionals at the Graduate Level

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A problem-based cooperative learning approach is described, focusing on courses taught to U.S. Army officers at Fort Leonard Wood, engineers at Boeing, and students at University of Missouri-Rolla. The utilization of modern tools such as the Web and computer-based instruction and assessment is also highlighted.

Engineering Education

The landscape of engineering is changing under the influence of economical and technological forces. Organizations are forming joint development teams that collaborate for the life of a project and then disperse. Quick response has become a major component of success and could be achieved by having companies join forces together and work in a virtual organization environment. To translate this to engineering education practices means to emulate the fast-track project environment, where teams members have seldom enough time to get acquainted, yet they are expected to operate as a highly effective team and deliver quality products on time and within a tight budget.

Training students to work in such an environment has been the driving force behind designing the structure of the courses described in this paper. An added uniqueness of these courses is the fact that they are taught mostly to professional graduate students at their work site.

The product-based-learning approach used in some of these courses has been praised in many publications (see references 1 to 4). Professor Leifer at Stanford University has described it as follows [5]:

> "Direct experience is the learning medium of choice in our domain of higher education and parallels the fact that professional experience is the measure by which most engineers, scientists and other professionals are rated.... . Learning is best done by creating something, a product, that embodies our knowledge. This is product-based-learning".

A background of the degree program within which these courses are taught will first be provided. Then four courses will be described, focusing on the approach that was used in each of them to make them effective.

Engineering Management Program

The University of Missouri-Rolla (UMR) is one of the four campuses of the University of Missouri system. UMR offers undergraduate degrees in 24 areas and graduate degrees in 19 areas. It has three academic divisions: The College of Arts and Sciences, the School of Engineering, and the School of Mines and Metallurgy. UMR is one of the nation's largest sources of engineering graduates.

The Engineering Management department was first established in 1965. The bachelor's program includes the basic chemistry, physics, mathematics, and engineering science courses required by all engineering disciplines at UMR. These courses are followed by core Engineering Management courses and students then specialize in five preference areas within three main fields:

- *Manufacturing and Packaging Engineering*: The focus is on design, operation and improvement of manufacturing and packaging systems.
- *Industrial and Quality Engineering:* The focus is on acquisition, analysis and interpretation of data in support of decision making, optimization and continuous improvement of quality and reliability.
- *Management of Technology:* The focus is on administrative aspects and decision-making in an organization including human relations, management principles, accounting, finance and marketing in a technological enterprise.

The MS degree program in Engineering Management is offered on the Rolla campus and as outreach programs at the UMR Engineering Education Center in St. Louis, Fort Leonard Wood, Columbia, industry and government installations in St. Louis, as well as to the National Technological University (NTU). More than 2,200 students have earned Master of Science in Engineering Management degrees from UMR.

Project Management Course at Fort Leonard Wood

A cooperative Master of Science program for U.S. Army officers is taking part in their Engineer Officer Advanced Course at Fort Leonard Wood.

In the cooperative program, officers enroll with UMR and take UMR courses while completing their Engineer Officer Advanced Course (EOAC). They then remain at Fort Wood for an additional 16 weeks of full-time UMR studies in UMR courses taught in the U.S. Army Engineer School. One of the keys to the program's success lies in the cooperative awarding of credit by both UMR and the U.S. Army Engineer School for engineering classes taken by the officers in their EOAC.

The Project Management course, EMgt 361, was taught as part of this program. The students had had prior instruction in project management network analysis and scheduling, but were not introduced formally to the management and planning issues involved.

The class was given a project goal: to write a how-to manual that can assist Army project managers in the development of a project management plan for a typical construction project. The class envisioned the final product as "a planning bridge between tactical and sustainment engineer operations". The class accessed for guidance the Web site of the Project Management Institute, "http://www.pmi.org", where a manual titled "A guide to the Project Management Body of Knowledge" was posted. The class was divided into groups or functional teams, each focusing on one project management knowledge area, such as Project Time Management, Project Quality Management, etc.... One group acted as the Project Office team responsible for project integration. Every group was responsible for devising a plan for its focus area and informing the rest of the class on the importance of this area and the issues involved to generate its plan. The groups were also responsible to work with the Project Office and other teams to integrate their work in the overall project plan.

The class met during 4 weekly sessions, each session lasting four hours. The fact that the students had had leadership training helped them get organized and focused quickly. Through weekly presentations and discussions, the groups learned the theory of project management and applied it to their term project. Time was allocated for the project office team to address the issues related to integration of the individual group work and to logistics.

The final product was a comprehensive manual, full of flow charts and checklists. The content was detailed, sometimes with conflicting information and overlap. The class as a whole agreed that this manual should be considered a first draft, to be reviewed by subsequent classes for refinement.

Feedback from the students was encouraging. The effort was thought worthwhile and the process effective. They felt that they were able to grasp the material quickly because of the focus that the project provided.

From the instructor's point of view, the goals set at the beginning of the class were about 90% achieved: the class worked as a team, experienced the behavioral, organizational, and technical issues involved in project management, and delivered a better than average final product.

The same approach will be repeated in a subsequent class. The class will be given the final product of the previous class and will be asked to refine it. Every session, the instructor will present the background theory and ask the class to tie it to the project. A committee from the U.S. Army construction and training divisions will be asked to set the scope of work and review the final product.

Case-based Advanced Engineering Economics at Boeing

Students enrolled in the Engineering Management program at Boeing are all professionals with several years of experience. With a course in Engineering Economics already completed and having been exposed to economic analysis on the job, a traditional teaching approach of an advanced course in engineering economics, EMgt 308, was believed inappropriate. Instead, a

guided problem solving/case studies-based approach was devised. The students reviewed the textbook material on their own, selected and solved problems, reviewed the solutions provided on the Web, and completed case studies for in-class discussion.

The World Wide Web was used extensively in this approach. Links to useful sites were provided on the class web site. These include the sites of professors at other universities who have been teaching in the area and who have been providing very useful information on their web sites. A partial view of the various links used is shown in Figure 1.

The University of Arizona (Professor Jeff Goldberg)
- Notes and Explanations
- Examples, Sample Exams, and Solutions
- Homework and Solutions
- example spreadsheets that you can download and run (Excel recent versions only)
- related links to ENGR ECON material, web browsers and search engines

Textbook author's home page (Professor Chan S. Park)
- Sample Test Questions
- Answers to Selected Problems
- Exam 1 / Solution
- Exam 2 / Solution
- Final Exam / Solutions Sample Test Questions
- Engineering Economics Web Site Resources

Sample Case Study (Professor V. E. Unger)

Figure 1. Sample Links Extracted from Class Web Site

Analyzing case studies using electronic spreadsheets turned out to be a very motivating tool. Students learned how to use of Excel software for financial analysis, were able to provide accurate and professionally-looking documents, and performed sensitivity and break-even analyses on their data. Such analyses would have been very difficult to perform without the use of computers.

During the second half of the course, the students took even more charge by forming groups and presenting chapters from the textbook to the class. After highlighting the major topics in the chapters, the groups shared with the class data on projects they were actually working on.

The "shying away from lectures and focusing on problem solving" approach proved to be an excellent way of teaching professionals who were self-motivated, mature, and eager to learn. This approach will be repeated whenever possible.

Computer-Based Learning of Project Management at UMR

On-campus students at UMR have ample access to sophisticated computer facilities. This was taken advantage of by structuring the Project Management course around computer-based multimedia modules (Figure 2).

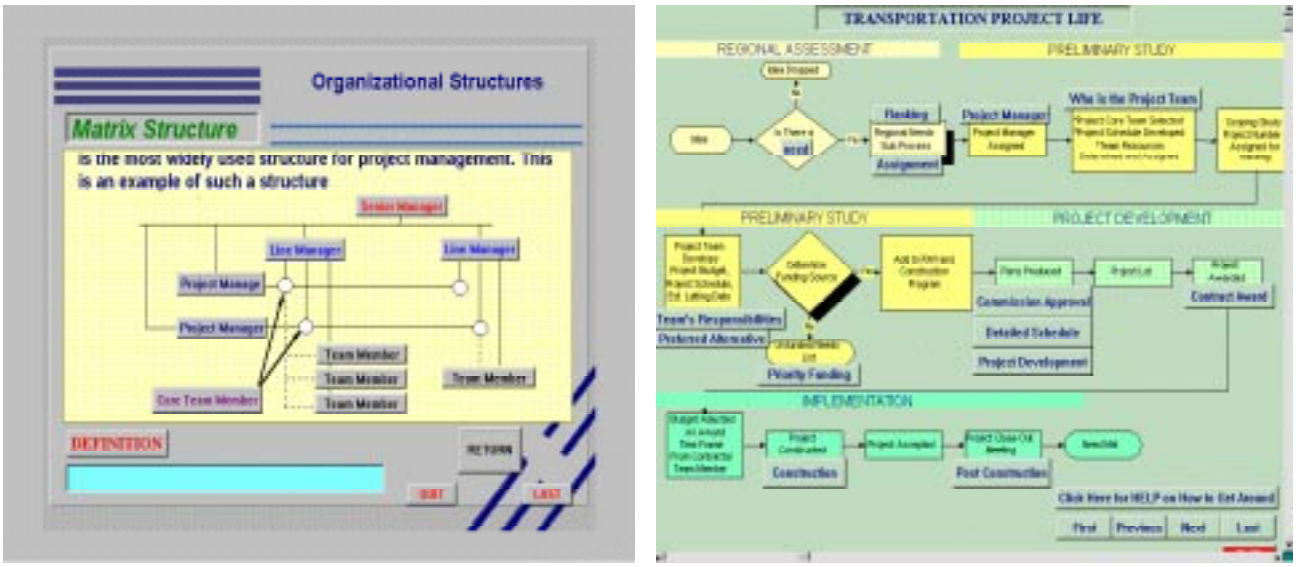

Figure 2. a) Screen for Overview Module b) Screen from Case Study Module

One module, "Overview of Project Management", is used during the first 2 weeks of class and provides supplementary material to assist in learning the basics of project management. It includes self-testing questions and is written in ToolBook Instructor II. [6]

The second module, "Project Life Cycle Case Study", is a description of how the Missouri Department of Transportation (MODOT) plans and implements projects. It is also written in ToolBook Instructor II. It is used as a reference upon which the group term projects are based [7].

The third module is the PMI's "Guide to the Project Management Body of Knowledge" described above and is accessed from the Web with Acrobat Reader software.

Throughout the class, the students are focusing on the information provided in module 2, the case study, trying to improve on the way MODOT should plan and manage projects. They derive their improvements and recommendations from their textbook, lectures, and especially the PMI guide.

A representative from MODOT is asked to be a liaison for information and review of the final project reports.

Interdisciplinary Problem-based Manufacturing Learning at UMR

In the Engineering Management 344 course, "Interdisciplinary Problems in Manufacturing Automation", students are required to work together as an interdisciplinary team, to produce a product based on customer requirements.

One class was given the task to design and specify the components of a computer-integrated engineering and manufacturing planning and control system according to the need specified in the following statement:

" To enable faculty and students explore the various facets of a computer integrated technological enterprise, CITE, an environment needs to be created where the appropriate software tools are available and integrated through smooth and user-friendly communication. The software would be selected based on the needs of various courses and as necessary to sustain a computer-integrated environment. The environment would also allow for innovative ideas to be tested and implemented. Research and what-if analysis would be as common as any other task undertaken in the facility."

Figure 3 was also provided to further illustrate the system's requirements.

The importance of the final design to the campus is made clear to the students. A Faculty committee has been asked to guide the development process and review the final design. The initial student feedback has been encouraging.

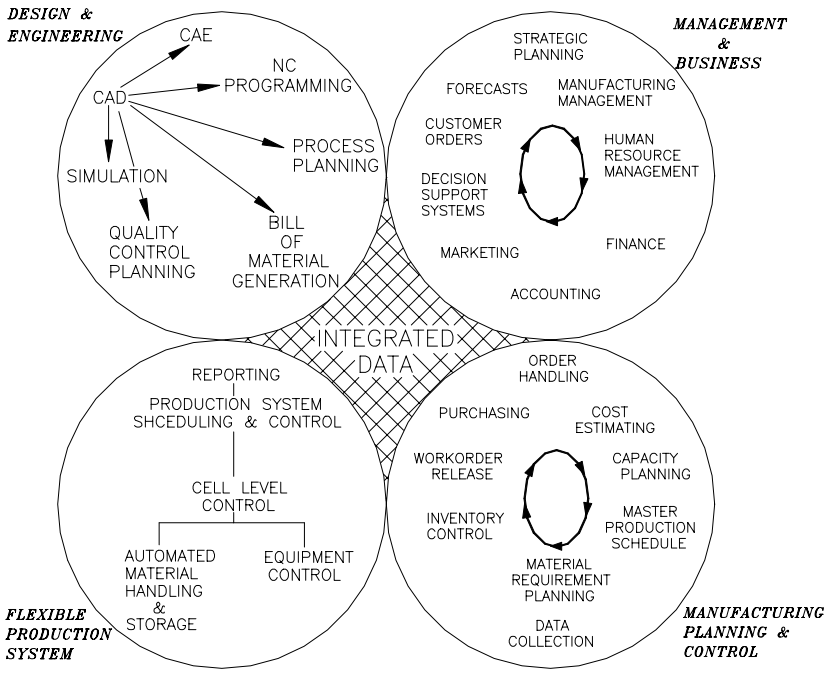

Figure 3. Functional Schematic of CITE's Engineering, Management and Control System

Conclusion

The use of innovative tools, such as cooperative learning, the World Wide Web and multimedia courseware, in teaching professionals has proven to be very effective and natural. Students and instructors have benefited from a teamwork-focused environment, industry-oriented, and objective-driven. These tools will be fine-tuned and used again in future courses.

References

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6- "Overview of Project Management", Computer-based-Instruction Courseware, Published in the NSF-sponsored National Engineering Education Delivery System (NEEDS) on-line Database, URL: http://www.needs.org/

7- "Project Life Cycle: Case Study", Computer-based-Instruction Courseware, Published in the NSF-sponsored National Engineering Education Delivery System (NEEDS) on-line Database, URL: http://www.needs.org/

Biographical Information

Dr. Najm is an adjunct associate professor at the Engineering Management Department of the University of Missouri-Rolla. He teaches courses and conducts research in project management and enterprise-wide integration. He is also an affiliated faculty member at the Instructional Software Development Center where he is involved in the development of computer-based multimedia courseware.

Dr. Najm received his Bachelor of Science, Master of Engineering and Doctor of Engineering degrees in mechanical engineering from Texas A&M University. He developed, integrated and installed several software applications in CAD/CAM, management planning and control, robotics, apparel design, and computer-aided process planning. He also developed AutoCAD-based computer programs to analyze building cooling/heating loads. He provided technical assistance to a variety of companies, including the Missouri Department of Transportation, Rawlings Corporation, Missouri Enterprise, Mid-America Manufacturing Technology Center, and DemMaTec Foundation.