GRADUATE EDUCATION IN ENGINEERING MANAGEMENT: THE CONCURRENT APPROACH – A CASE STUDY

Cristina Cosma¹, Zohar J. Herbsman², and Jose D. Mitrani³

ABSTRACT

The paradigm shift in concurrent engineering is that a multidisciplinary team of experts with different roles and perspectives performs the engineering and construction tasks. The interaction between team members will affect not only the characteristics of the product, but also the structure, norm and culture of the organization, having further influences on the engineering and construction process and further downstream on the final result.

The paper analyses the main obstacles that show up in the implementation of concurrent engineering in the construction industry. People issues are being emphasized. The authors suggest that personnel training in this area is a key factor in realizing the bottom line goals. Different training trends are being presented.

Offering “in-house” training towards a graduate degree is becoming a feasible concurrent solution. Financial and logistical support to such a program is to be provided by the organization. This solution will enable engineers to work full time and at the same time get their degree without having to give up their job. The advantages for the organizations offering convenient access to advanced education, is that this educational system can help them recruit top people, as well as motivate existing employees.

In 1995 the Department of Civil Engineering at University of Florida started a training program that is offered in the Army Corps of Engineers in the Jacksonville district. The paper will analyze the conclusions drawn from seven years of conducting this program and will discuss some problems that had to be overcome.

KEY WORDS

Concurrent Engineering, implementation, concurrent teams, delivering training.

¹ Ph.D. candidate, Department of Civil Engineering, 124 Yon Hall, PO Box 116580, University of Florida Gainesville, FL.32611, 352/846-1514, ccosma@ufl.edu
² Professor, Department of Civil Engineering, 124 Yon Hall, PO Box 116580, University of Florida, Gainesville, FL.32611, 352/392-0935, FAX 352/392-3394, zohar@ce.ufl.edu
³ Professor, Department of Construction Management, Florida International University, CEAS 2982, FIU, Miami, Florida, 33199, 305/348-3654, FAX 305/348-6255, mitrani@eng.fiu.edu
INTRODUCTION

The construction industry has been moving towards concurrent engineering (CE) for many years (Katranuschkov et al. 1996). Despite this tendency, the level of success achieved in practice through the application of concurrent engineering is still far away from the expectancies. The different levels of training and experience of the personnel involved in the construction business in combination with other organizational particularities have a limiting effect on the level of concurrency and collaboration of work to be achieved.

Concurrent engineering issues, such as the management of the process, product, documentation, and communication, are still being handled in a fragmented manner. But fragmentation creates professional dissonance and this is bad for innovation (Whyte and Edge 1999). Interoperable environments have yet to be developed which can fully integrate into practice and increase the uptake of concurrent engineering.

The paradigm shift in concurrent engineering is that a multidisciplinary team of experts with different roles and perspectives performs the engineering and construction tasks. Their role is to contribute to the tasks collaboratively by making decisions and sharing the information with each other. Dynamism is another characteristic of these “concurrent teams” as participants keep on evolving and continuously interacting during the holistic lifecycle of construction process. This interaction will affect not only the characteristics of the product, but also the structure, norm, and culture of the organization, having further influences on the engineering and construction process and further downstream on the final result.

One of the most important governmental organizations strongly committed to the implementation of concurrent engineering is the Army. In their mission to design, maintain, and rehabilitate the Army's infrastructure and to sustain installation environmental quality the Army Corps of Engineers is engaged in developing the techniques, strategies, and tools to provide Army planners, designers, construction managers, and facilities operations managers with the basis for better decision making. The efforts include the development and advancement of technologies from which concurrent engineering is one important area.

Personnel training in this area is a key factor in realizing the bottom line goals. Corporations have even established their own universities to provide company-specific training to their employees. Offering an “in-house” graduate degree is becoming a feasible concurrent solution referring to the fact that the students will have the potential of executing in parallel two different tasks: working full time and getting their degree without giving up their job. Financial and logistical support to such a program is to be provided by the organization. The advantages for the organizations offering convenient access to advanced education, is that this educational system can help them recruit top people, as well as motivate existing employees.

In 1995 the Department of Civil Engineering at University of Florida started a training program that is offered in the Army Corps of Engineers in the Jacksonville district. The program was using three different lecturing tools like: professors traveling to organization’s location to teach graduate classes there, graduate courses offered on videotape (FEEDS), and finally on-line courses (Internet).

The paper will analyze the conclusions drawn from seven years of conducting this program and will discuss some problems that had to be overcome. The authors believe that
such a program can be developed for almost any midsize to large organization. Steering the experience in outsourcing from this program will enable other universities to develop similar programs in their area.

IMPLEMENTING CONCURRENT ENGINEERING

The implementation of Concurrent Engineering addresses three main areas: people, process, and technology. It involves major organizational changes because it requires the integration of people, business methods, and technology and is dependent on cross-functional working and teamwork rather than the traditional hierarchical organization. From the problems encountered by companies in the process of introducing Concurrent Engineering, lack of training in the teamwork was often mentioned.

Participants in the panel discussion at the 2nd International Conference on Concurrent Engineering in Construction (CEC99) pointed out that CE is primarily about people and how to get them working synergistically. They supported the idea that overall the focus has to be on people as the main driving force of concurrent engineering initiatives. A primary need identified to contribute for a successful implementation of CE in construction is to eliminate the gap between industry and academia (CEC99). In order to build a bridge between the two parties a concurrent approach has to be taken: academia and industry should co-operate as an integrated multifunctional team.

One major obstacle to be noted in the interaction between academia and industry is that they both "speak a different language". In order to mutually identify, understand, and then solve the organizations' problems researchers should be invited to visit large organizations (CEC99). Smaller organizations might not formally require concurrent engineering, because they naturally operate in this form (Ainscough and Yazdani 2000). One of the reasons of poor academia-industry interaction lie in the fact that the industry fails to appreciate the applicability of the research findings of academia because they are not really addressing the issues and needs of the industry. A “customer focused” approach, where the customer is none other but the industry, is one of the solutions (CEC99).

CONCURRENT TEAMS

Concurrent engineering brings together multidisciplinary teams, that we would name “concurrent teams” (CT), in which product developers from different functions work together and in parallel from the start of a project with the intention of getting things right in a timely and efficient manner. Sometimes, only design engineers and production engineers are part of a CT. In other cases, the CT includes representatives from purchasing, marketing, production, quality assurance, the field and other functional groups are part of a CT. Sometimes customers and suppliers are also included in the team.

One of the greatest challenges in managing the simultaneous operation of inter-related tasks is to figure out ways that get people to work together as a team because human beings have a natural tendency to be territorial and are likely to attach top priority to personal interests (Prasad 1997). Creative win-win solutions have to be found in solving interpersonal and/or intergroup conflicts. Another important aspect is training CT’s on dealing with change during the entire life cycle of a product. Communication between team members should flow
freely, unrestricted by personal, physical or semantic barriers. Finally, success can be achieved only if the CT is customer focused.

**DELINEATING TRAINING**

The growth of the Internet has created new avenues for training. Web-based technologies provide many benefits in delivering training and educational services, some of which include (a) relatively low cost, (b) real-time, and (c) ease of access to sources of knowledge. Many companies express their willingness to provide necessary infrastructure such as computers and Internet access so that their employees may receive training as needed and pursue the goal.

The change in the training environment, as well as the broad range of potential users of concurrent engineering techniques, requires a thorough analysis of the knowledge that will be required for intelligent and effective use of the new model. Identification of subject areas that will be need to be addressed and recommendations for implementation in training programs should be developed.

From the training trends discussed by education specialists the following are mentioned most often (Heathfield 2002):

1. Multimedia and on-line training. The American Society for Training and Development (ASTD) conference in Dallas noticed a proliferation of online providers of educational sessions. The current move in organizations has been to offer training on CDs, but the Web-based training (WBT) is not far behind. The quality of the courses varies as does the amount and type of multimedia used in their presentation.

2. Electronic Performance Support Systems (EPSS) are an additional topic generated by WBT. Dealing with the interface between people and software and creating and offering courses that trainees will actually finish are two main concerns. An attempt to move traditional manual-based courses online resulted in courses looking like training manuals online’ depleted of the Web advantages of interconnectivity and the ability to publish real-time, up-to-the-minute information. Integration of a real, live instructor and peer interaction with Web-based or CD training is still under discussion.

3. Performance consulting. Emphasis in training is now placed on providing a range of potential solutions that include in-depth needs assessment via interviews, surveys, and focus groups. Alternatives to training offered by progressive human resource departments include coaching, organizational development or planned change consultation and interventions, facilitated planning sessions, and large group processes. Training provided is custom-designed with stated outcomes congruent with the direction of the business.

4. Performance management. Integration of training and development into an entire performance management system is another trend. Organizations are moving away from the long-established one-on-one appraisal or performance review with a boss once per year. They are designing performance management systems that provide an individual with more frequent feedback from many points of view including peers, direct reporting, staff members, and the boss. The feedback, known as 360-degree feedback, provides a more balanced set of observations for the employee. The performance management
system also integrates a performance development plan for the individual designed to assist the employee to continue to develop his skills and abilities. For these plans, preference is accorded to integrated corporate university courses and internally custom designed and presented training. Performance development plans may include coursework, but also provide learning activities on the job such as special projects, serving on cross-functional teams, and skill stretching job assignments.

CASE STUDY

GENERAL INFORMATION

The University of Florida was approached by a major engineering organization, the Army Corps of Engineers, about the possibility of offering a master’s degree in construction/engineering management. This organization has in its Jacksonville district around 150 engineers, architects, and related professionals that would like to pursue their graduate degree. The Army Corps of Engineers made it clear that they would support the program but because of budget and manpower limitations their employees would not be able to travel to Gainesville where the University of Florida is located.

The army estimated that the cost of sending an employee for 18 months to the University in order to get a Master’s degree is close to $120,000. Because of those high expenses, the Army could send only one employee per year for full time studies. A preliminary survey showed that 30-40 Army engineers would like to participate in the program.

Trying to respond to the industry’s needs, the University of Florida has decided to offer a Master’s degree program in Jacksonville using distance education tools. The program developed at University of Florida was designed to satisfy user’s training needs.

PROGRAM

The Master’s degree currently offered to the Army Corps of Engineers is a regular Civil Engineering Master’s degree which includes 32 credit hours of which 12 credits have to be in the major area of engineering management. The rest of the credits can be from various areas of civil engineering and related management areas. All the students will have to submit a Master’s report before the completion of their studies. As of the end of 1997, twenty students participated in the program. The majority of them finished 50-70% of the required credits. Two students were able to complete their degree by coming to the University as full time students for a short period of time.

The second cycle of the Army employees pursuing their master’s degree started in 1978 and 10-15 new students joined the program. This experiment has gotten a very positive reputation around Florida, and other organizations like the Department of Transportation, public works organizations (Sarasota County) are trying to participate in similar programs.

CONCURRENT APPROACH

Students accomplished their tasks by working in concurrent teams that focused on various aspects of engineering design, production, and construction management. Appendix 1 and Appendix 2 offer an example of an in-class assignment and a term project assignment.
respectively, both designed to make students work in teams. Assignments were also designed specifically to develop in students the ability to acquire and interpret information, to manage information, to communicate information, to apply information to specific tasks and be innovative, and to apply all these competencies in a multi-disciplinary context. Working in teams required students to develop skills in group dynamics, compromise, debate, persuasion, organization, leadership, and management skills.

In this new CT approach, students had to explicitly communicate and think about sets of alternatives, which were finally narrowed, converging toward a single solution. The CT’s had to roughly explore the “design space”. The instructor defined a set of constraints in order to help the teams getting to a final solution. Teams were able also to identify intersection points between each other’s sets of alternatives and do benchmarking.

One of the primary issues was the formation of teams. Collaboration rather than individual effort was the standard, and team members realized that shared information is the key to success. Team members had to commit to working cross-functionally, be collaborative, and constantly think and learn. The role of the instructor was more as of a coach than a leader. He/she supplied the basic foundation and support for change rather than to tell the team members what to do. By chance team members had different educational backgrounds. Civil engineers, mechanical engineers, electrical engineers, and chemical engineers had to work together to complete a task. Instructors used this aspect to simulate the concurrent environment, and also to familiarize students with integrated teamwork.

**Educational Tools Used in the Program**

The following educational tools were used in the case study. Their advantages and disadvantages will be discussed in the following pages.

**Distance Travelling**

A few of the professors were ready to travel to Jacksonville in order to teach in-house graduate courses. The distance created some administrative problems, but with the use of e-mail, phone, and fax, most problems have been solved. This method was the best one regarding interaction between the professor and students. However, this method is very expensive and time consuming. Total cost of teaching 2-3 credit hours was $15,000, including lecturer’s fee (over the regular salary), travel, per diem and administrative cost. When the course was a required one, 25-30 students participated in the course and the cost per student was around $500/student per course, compared to regular fees at the University of Florida of $400/student. This difference was acceptable for the Army. However, when classes were elective, only 10-15 students participated and the cost per student was very high. The second problem was that most of the professors consider this method to be very exhausting (it is a full day of work) and only a few were ready to continue doing it.

Printed materials have been used extensively in this case because of the advantages they offer, like spontaneity, perception of being non-threatening, and the cost effectiveness. Disadvantages like outdated material and lack of timely feedback from the instructor can be solved easily by more advanced means of communication:
VIDEO COURSES

For many years, the University of Florida has offered courses that were taped in studios in Gainesville and the videos were sent by mail to various locations. Each student could watch the tape at home/work and participate in the class, homework were sent to the lecturer by mail, tests were done in-house with some security system.

This system is economical and very efficient. The cost for the students was like regular course tuition. Because of the extra efforts of the lecturer there has been university discussion to increase such course tuition by 25% and to give to the lecturer some monetary incentive. The major disadvantage of this method is not having any direct interaction between the professor and the students and both parties admit that this way of teaching is less beneficial than regular teaching.

VIDEOCONFERENCES

Videoconferencing offers the capability to broadcast audio and full-motion, to slow scan, and to freeze-frame images over a closed circuit to one or more locations. One of the advantages of videoconferencing is the visual connection established among the participants. Conversation and body language can be used to enhance communication. Some of the advantages of videoconferencing include that frequent interaction increases understanding, and the method involves convenient access to remote experts, besides, the preparation and training for this media is minimal. This method also offers document sharing for collaboration. The falling cost of equipment is contributing to the increased use of videoconferencing. A $50,000 mid-range rollabout video-conferencing system costs about $10,000 per year when depreciated over five years.

In this method the lecturer was teaching his regular courses for the full time students at Gainesville, however he was doing his lectures in the distance education studio. Using telephone connections his lecture was transferred to the Army studio in Jacksonville. The Army studio included a few video monitors and video cameras. When any participant in Jacksonville had a question or a remark he/she called the studio in Gainesville establishing an audio-visual communication. There were some delays in communication time but after some early technical problems, the system was working very well. The major advantage with this method is the interaction between the professor and the students. In the future, this method will become the major tool for our distance education program. Economically, it is not expensive when using telephone lines. The cost of the 2 studios is substantial but it can be distributed over many courses and for many years. The major disadvantage of this tool is that the professors have to get used to the new media and they would need training and more time for preparation.

One of the major conclusions from using this method was to video tape the lecture at the source (university) and to send the tape (by fast mail) to the students in Jacksonville (they got it the next day). The tapes from the source were of a much better quality than the recording in the Jacksonville studio.

INTERNET COURSES

Internet is the largest and most powerful computer network in the world. It is used by more than 30 million people in more than fifty countries, and current estimates suggest that over
four million computers are part of the Internet (Kochmer 1991). Universities, schools, companies, and private citizens can have access to the Internet either through affiliations with regional not-for-profit networks or by subscribing to information services provided by for-profit companies. This new media has opened a large variety of possibilities for distance educators to overcome time and distance to reach students. Instructional possibilities of the Internet include electronic mail (e-mail), bulletin boards, and worldwide web (WWW).

A few professors are developing courses on Internet. This is in an experimental stage and the idea is that all the course material will be offered on the Internet. A recently developed course at University of Florida, using Internet WWW is “Basic Traffic Operations” (Figure 1). This method has many advantages if the right type of course is chosen. It will fit to those courses that are very defined and have few discussions. The authors’ opinion is that courses like cost estimate, scheduling, legal, and similar courses are suited to this media. The major disadvantage of Internet courses is that developing a good course of 2-3 credits takes substantial resources (time, money). From the authors’ experience it will take at least a year of hard work to develop a course using Internet.

![Figure 1: Course offered on Internet WWW at University of Florida](image_url)

**FEEDBACK**

The U.S. Army Corps of Engineers Jacksonville District's 232 person Engineering Division has a large, diversified and complex civil works program. Major engineering features in their $59 million program include flood control, navigation, beach erosion, concrete, rock and earth-fill dams, jetties, levees, dikes, bridges and environmental restoration engineering. The Division utilizes professionals with expertise in hydrology and hydraulics, soil engineering, geology, surveying and mapping, cost engineering, structural, mechanical, electrical, and
civil engineering and architecture. Approximately 50% of the Division’s work is accomplished by other Corps districts or private sector Architect Engineering firms operating under the direction of the Division's technical staff. State of the art computer equipment is used to develop complex models for conceptual planning, analysis, visualization and detailed design as befits a high technology modern engineering organization.

Management recognized that education is a critical variable for this professional engineer based organization. An assessment revealed the following:

- Lack of advanced degrees or course work by many of the current staff.
- Lack of graduate training opportunities in engineering and engineering management in the Jacksonville area.
- Concern over the expense of sending students out of the city for graduate courses.
- Unwillingness of the students to take all or most of their courses by video tape distance learning.
- Potential recruits increasingly expressing the desire to locate where they can continue their education.
- Existing staff’s strong desire for graduate training indicating such a program would serve as a retention tool.
- Recognition that many of the people that we deal with from outside the Corps have graduate degrees.

Management has a strong desire for the local courses to become part of a larger continuous learning initiative utilizing multiple forms of training. The University graduate courses offered both locally and by long distance complement training offered by the Corps and available short courses. These training opportunities are incorporated into a training plan for upgrading each individual's skills. Where possible the University Professors would spend periods of time working at the Corps. This has a dual benefit. It provides the Professor the opportunity to work on real world problems. It provides the student with an opportunity to interact with the Professor in applying higher level considerations to their regular problem solving.

Management is pleased with the graduate training that our people have received as well as the interest in all advanced training that this program has helped foster. We have had 4 students receive their Masters Degree and several others are moving in that direction. There is a high level of interest in all learning and we have had over 60 students explore participating in the after work graduate classes. After much effort by all, the in-house degree program has more than met our expectations.

CONCLUSIONS

Concurrent Engineering (CE) has become more and more an important paradigm in product development and also a widely accepted concept within the industrial and academic arena. The key to CE lies in concurrent exploitation of people, technology, processes, and products.
This is possible through cohesiveness and commitment by learning from and teaching others, and then taking several steps beyond in search of CE enlightenment.

Concurrent Engineering in construction will require true collaborative working between client representatives, construction professionals, suppliers and subcontractor organizations. The information technology required to facilitate such collaboration largely exists already. The barriers to the introduction of these technologies and efficient effective collaboration are human and organizational.

Training addressed at getting people to work together in teams plays an important role in the successful implementation of CE in construction. From the seven years of directing the training program at the Army Corps of Engineers the Jacksonville district the authors consider that overall the program is a success.

The authors concluded that training for concurrent engineering requires different media than conventional education does and it requires special training and specialization. Using a combination of educational/training tools is considered to be a good solution for concurrent training. Following the “concurrent way of thinking” both trainers and trainees should co-operate in establishing what tools to use.

REFERENCES


APPENDIX 1

CORPS OF ENGINEERS
SPRING TERM 2002

IN-CLASS ASSIGNMENT
Review the requirements of the Term project

IN YOUR TEAMS, DEVELOP A PLAN FOR COMPLETING THIS ASSIGNMENT

The plan should include:

1. Selection of projects to be used
2. Major work items to complete the term project
3. Major milestones
4. Time for completing work items (schedule) and meeting milestones
5. Responsibility matrix for team member performance on work items
6. Contract agreement for team members that outlines
   a. Team goals
   b. Meeting times
   c. Agendas
   d. Meeting responsibilities
      i. Note taking
      ii. Informing (contracting)
      iii. Action items
   e. Rules for team members
      i. Attendance
      ii. Notification
      iii. Conduct
      iv. Responsibilities/obligations
7. Consequences for non-performance team members

DUE DATE: __________________________
APPENDIX 2

CORPS OF ENGINEERS
SPRING TERM 2002

TERM PROJECT ASSIGNMENT: Your term project requirements are as follows with adjustments to these requirements to be made by addendum:

PROJECT GOAL: To produce a project oriented manual

1. Each team is to select a project on which they will work
2. Chapter 1 - Create a flow chart showing the project organization that you will be using
3. Chapter 2 – Create a “line and staff” organizational chart
4. Chapter 3 – Create a schedule for the final program
5. Chapter 4 –
   a. Create an outline of the major work items for the projects
   b. Develop a CM proposal to the owner
   c. Develop a “procedural outline”
6. Chapter 5 – Develop a listing of the “Special Conditions” that would influence the project beyond that of ordinary specification requirements.
7. Chapter 6 – N/A
8. Chapter 7 –
   a. Refine your organizational chart to reflect the development of the project from 1 above until now
   b. Create additional organizational charts for:
      i. The project change process
      ii. The payment process
9. Chapter 8 –
   a. Refine the description of major work items to reflect any changes and to include budgeted cost
   b. Include a manual section on procedures for “cost control”
10. Chapter 9 – N/A
11. Chapter 10 – Create a project communications requirement and process flowchart for achieving your communication goals
12. Chapter 11 – Using reference such as “Means” create an estimate for the project based on your major work items (Compare with your original estimate)
13. Chapter 12 – Dr Herbsman will provide as an addendum
14. Chapter 13 – Create a work-breakdown structure for 3 of your major work items
15. Chapter 14 – For all of your major work items, create a procurement schedule
16. Chapter 15 – N/A
17. Chapter 16 – Develop an Outline for QA/QC program for this project
18. Chapter 17 – Create an organizational chart and plan for your project safety program
19. Chapter 18-19 – N/A
20. Chapter 20 – Create a flowchart on how to plan and handle dispute resolution on this project