

Building Capstone Design Course on Construction Management within Civil Engineering

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Abstract----The Civil Engineering Department at Kuwait University introduced a capstone design course in the field of construction management. Construction Management is considered a specialty program within the civil engineering curriculum of Kuwait University. The course experience is designed to be similar to what student might expect in a real life, in which a real life construction project is chosen as case study for the course. In this capstone course teams carry out the project work with students acting as construction managers on each of the phase of a construction project cycle. Estimation, plans and written reports are required for each phase. At the completion of the project each team gives an oral presentation. Evaluation of the capstone course has proved to show student responses has been very positive.

Keywords---- Building Capstone Design Course on Construction Management

I. INTRODUCTION

CONSTRUCTION project managers were normally appointed with an extensive experience in the construction industry as the only qualification. However that gave no assurance of project success. There was no formal education and training in what was then the new profession. Quality construction education of newly graduate engineers should permit the appointment of able construction project managers. A special curriculum was designed for the senior level at the Civil Engineering Department of Kuwait University that was reviewed and evaluated by the Accreditation Board for Engineering and Technology (ABET) of the United States. This curriculum was introduced in 1992 and still being offered by the department. The students can specialize in one of six sub-specialties (i.e. structural, transportation, geo-technical, environmental, water resources and construction management). The civil engineering students, when specializing in construction management track, have to take complete two required construction management courses; CE435 "Construction Engineering and Management" course, and CE430 "Legal, ethical and professional Aspects". Then, students majoring in construction management are asked to take two courses CE434 "Construction Cost Estimating", and CE437 "Construction Methods" and a capstone design course. The capstone design course is entitled CE493 "Construction Engineering and Management Design". This course teaches the undergraduate civil engineering students how to plan, schedule,

and estimate a real life construction project and has the objective of teaching them the basic construction project management skills.

The students are divided into groups of three, and are assigned to a real life construction project and supervised by a faculty in construction management along with a professional engineer from the construction industry. The course is divided into four major phases. The first phase is the *pre-design* phase that incorporates the procedures that a project manager should be familiar with before signing an agreement with a design professional office, and how to define and understand scope management procedures. The second phase is the pre-construction phase that teaches the students the contractual and specification documents and procedures that takes place before the signing the construction contract with a successful bidder. Also, in this phase students practice cost estimating procedures. The third phase is the construction phase that teaches the students the procedures of running the project during execution, the time management procedures, and how to develop a schedule. The fourth is the progress and project control phase, in which the students are required to submit a real project progress report of the real project that were assigned to for a particular month period of that project. Each phase ranges from 3 to 4 weeks and each group have to submit a report and make an oral presentation by the end of each phase. The paper has the purpose of presenting the details of this construction management program and the capstone design course. Evaluation of the course is also presented in this paper.

II. EDUCATION PROGRAM AT THE CIVIL ENGINEERING DEPARTMENT - KUWAIT UNIVERSITY

Kuwait University (KU), which was established in 1966, opened the College of Engineering and Petroleum (CEP) in the fall of 1975, which has developed into a credible engineering school. The number of undergraduate has increased from 127 students in 1975 to more than 2,400 students in 1998. The engineering programs were evaluated three times (1981, 1990 and 1995). Results of all evaluations were extremely positive (ABET Reports 1990 and 1995). In their 1990 report, the ABET visiting committee stated "Based on our evaluation, we believe each of the program examined would be accredited, were they to be subject to the full process. In comparing these programs with engineering programs in the United States, we would expect them to rank at the level of about 25% from the top".

Thus, one of the major goals set by the Civil Engineering (CE) department is the dissemination of high standard education to ensure the preparation of graduates capable of

coping with challenges in practice. To achieve this goal, an educational program at the CE department has been developed according to reputable international standards adapted to Kuwaiti needs. A distinguished characteristic of this program is a coherent curriculum designed to give students a strong background in the basic fields of engineering. It is divided almost evenly between a core component, common to all engineering students, and a set of specialized courses of direct relevance to all students' field of specialization. Each student majoring in CE must satisfactorily complete a minimum of 144 credits.

III. THE CAPSTONE DESIGN IN CONSTRUCTION MANAGEMENT AND ENGINEERING

There is some common subject matter among almost all construction educational programs. Courses generally include planing and scheduling, estimating and cost control, and contractual and legal aspects. The ABET have put more emphasis on design in undergraduate civil engineering curriculum. In response to this, the CE department at KU introduced a capstone design course on each of the above mentioned sub-disciplines. The capstone course that was structured for the construction management program discipline is entitled CE493 "Construction Management and Engineering Design". The course involves team participation by the students, under direction of a faculty member in the construction management program. Each team serves different roles in the different phases of the course.

The capstone design course is a major engineering design experience that emphasizes in the development of student creativity, the elaboration and use of construction methodologies and evaluation of alternative solutions. The purpose of this course is to prepare the students to conduct construction engineering and project management responsibilities in a real life-project. The course provides a practical, state-of-the-art view of key topics in construction engineering and management and presents the principles and techniques of project management beginning with the conceptual phase by the owner, through co-ordination of design and construction, to project completion. This course presents these principles that apply to all project managers and projects and illustrates the basic steps, and sequencing of steps, to develop a work plan to manage a project through each phase from conceptual development to completion.

Arrangement of this Course. A discussion of project management is difficult because there are many ways a project can be handled. One or more parties can perform the design and/or construction of a project. Any construction project has a distinct life cycle, starting with an idea and progressing through design, engineering, and construction, through use by a project owner. Project management is the art of directing and coordinating human and material resources throughout the life of a project by using modern management techniques to achieve predetermined objectives of scope, cost, time and participant satisfaction. Regardless of the method that is used to handle a project, the management of a project generally follows these phases:

Phase 1: Project Definition (to meet the needs of the end user)

- Intended use by the owner after completion of construction.
- Conceptual configurations and components to meet the intended use.

Phase 2: Project Scope (to meet the project definition)

- Define the work that must be accomplished.
- Identify the quantity, quality, and tasks that must be performed.

Phase 3: Project Budgeting (to match the project definition and scope)

- Define the owner's permissible budget.
- Determine direct and indirect costs plus contingencies.

Phase 4: Project planning (the formulation of a strategy to accomplish the work)

- Select and assign project staffing.
- Identify the tasks required to accomplish the work.
- Arrangement of resources in a systematic manner to fit the project plan.
- Selecting individuals who have the expertise to produce the work.

Phase 5: Project Scheduling (the product of scope, budgeting, and planning)

- Arrange and schedule activities in a logical sequence.
- Link the costs and resources to the scheduled activities.

Phase 6: Project Tracking (to ensure the project is progressing as planned)

- Establishment of a system to measure.
- Compare "actual" to "planned" work, time, and cost.
- Report, and forecast deviations in the project scope, budget, and schedule
- Measure work, time, and costs that are expended.

Phase 7: Project closeout (final completion to ensure owner satisfaction)

- Final testing, inspection, and payment.
- Turn over of the project to the owner.

Course Subjects. The capstone design course is divided into phases, which matches the project lifecycle as mentioned above, with a progress report and set of plans are required for each phase by each team. In addition, a final written report and an oral presentation are required. At the beginning of the course an on-going real life project is chosen as case study for their course. Projects that have been chosen vary from one course to another. Such real-life projects include the Scientific center project (valued KD30 mil), the Sharq waterfront complex (valued KD36 mil.), the college of Administrative sciences at KU project valued (26 KD mil.), etc. The course starts with the explanation of the course objective and invites the project manager of the real-life project to brief the students on the project and go on a site visit to the project. Then students are then divided into teams to start on working on the following phases of the course.

Phase I: Pre Design Phase (4 weeks). The students assume the project has not started and a client has the idea of building that particular real-life project in which the client hires them to provide him/her with the following items:

- a. Determine the space requirement program by conducting a survey with the intended user of the project.
- b. Determine preliminary cost estimate (Budget) based on overall capacity determined from the above phase.
- c. Conduct a feasibility analysis study for the project to compare the funding approaches to be considered by the user.
- d. Constructing a call for Professional Services (Terms of reference) proposal
- e. Constructing a draft agreement between the owner and the consultant Construction and Owner
- f. Development a master schedule that shows milestones and important events of the project phases.

Phase II: Pre Construction Phase (4 weeks). The teams are assumed that the design phase of the real-life project has completed and is working as construction manager in the pre construction phase to perform the following items of work:

- a. Defining construction work and listing the activities of the project.
- b. Estimating the quantities and direct cost items (i.e. resources required to install these quantities) and indirect cost items involved in the project.
- c. Design Management (vs. Value Engineering). The teams are exploring the application of the value engineering concepts using one case study.
- d. Tendering, in which the teams are incorporating the general conditions and contractual documents needed in a tendering and bidding procedures.

Phase III: Planning and Scheduling Phase (3 weeks). The teams are assumed to work as planners for the contractor to perform the following items

- a. Preparing a project schedule network using the critical path method (CPM).
- b. Loading the resources and cost items into the CPM activities using project management software.

Phase IV: Construction Phase (3 weeks). The task here is to do a progress report writing, in which the teams collect actual data in a particular period of the real-life project and compare it with the planned information and produce a progress report.

In each of the above phases, the students can have a presentation from a professional engineer from that particular real life project to highlight the methods and procedures taken in that particular phase. The course was started in fall 1994 in which the class breakdown was A real construction project was selected on every course that was offered. The project used to represent the major phases of a project cycle as:

Course Requirements. Although the scope of this course is extensive, the student should complete and take some the courses in construction management program. These courses are:

1. CE 430 Legal, Professional and Social Aspects of Engineering. (3 credits). A required course for all civil engineering students. This course teaches the students

types, procedures and documents of contracts in the construction industry, the legal obligations and roles of the parties in a contract. The development of the concepts of professionalism and ethics and the traditional practice of these concepts are considered in relation to changing situations in practice in the variety of employment conditions.

2. CE 435 Construction Management and Engineering (4 credits). A required course for all civil engineering students which teaches the students the concepts of planning, scheduling and controlling for construction operations. Employment of major equipment and estimation of their productions is also taught in this course.
3. CE 434 Construction Estimation and Cost Control. (3 credits) An elective course, which is needed for the construction management discipline. In this course, the fundamentals and concepts of estimating, and the phases of cost estimating is offered. Pricing and bidding procedures and computer tools are also part of the course.
4. CE 437 Construction Methods. (3 credit). An elective course is also part of the construction, management disciplines. The course covers the types and description of methods used in the planning of construction operations. Employment of major construction equipment and estimation of their production is also covered.

IV. COURSE EVALUATION

All students take part in the oral presentation at the end of the semester. Each team gives a summary of the phases and each student in the team explains his/her role in each phase. The oral presentation is 45 minutes per team. The team must plan and organize the presentation in a manner that all major aspects of the project are addressed. The grading system was structured as illustrated in the evaluation sheet shown in Table 1. Categories of the grading system are individual performance (15%), group performance (15%), reports (50%) and finally the oral presentation (20%). Each category is further divided as shown in Table 1 with the corresponding weight as a percentage. The individual rating is intended to motivate each student to work to best of their ability within his/her group. The group rating is the same for all members of the group. The reports submitted on each phase and the final report has half of the grade. Finally the oral presentation is evaluated based on the organization of the presentation and skills of the group and tools used in the presentation.

After the oral presentation is finished a question and answer session is followed to test each student on the contribution and knowledge on different issues with project phases. The faculty member and one professional construction manager fill their evaluation for each group and for each individual within each group. Both evaluations are average and multiplied by the weight given for each item in the evaluation sheet.

V. SUMMARY AND CONCLUSION

Construction management is now well established as an alternative to civil engineering students. The sub-specialty majoring within the students and the capstone design course

provide more professional orientation to the curriculum. Responses from students have been positive. At the end of the capstone design course, students have the opportunity to anonymously evaluate the course. An open discussion with the students at the end of their final oral presentation is also generated to evaluate the benefits that the students have gained

from this course and with the interaction with a real-life construction management experience. So far the responses were very positive that they rate the capstone design course to be a valuable experience, and that they are confident enough that they can approach similar situations after they graduate

TABLE I
BREAKDOWN EVALUATION OF STUDENTS

(1) Category	(2) Item	(3) Weight	(4) Performance	(5) Score 3 * 4	(6) Comments
Individual:	Attendance:	5%			
	Participation:	5%			
	Leadership:	3%			
	Q/A understanding:	2%			
	Sub-Total	15%			
Group:	Team work	5%			
	Coordination	5%			
	Cooperation	5%			
	Sub-Total	15%			
Reports	Completeness & Integrity	25%			
	Depth & Quality of Work	10%			
	Timeliness	5%			
	Organization	5%			
	Originality & Creativity	5%			
	Sub-Total	50%			
Presentation	Organization	5%			
	Skills	10%			
	Tools	5%			
	Sub-Total	20%			
Total :		100%			

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