Sixth International Conference on Construction in the 21st Century (CITC-VI)
"Construction Challenges in the New Decade"
July 5-7 2011, Kuala Lumpur, Malaysia

Importance and Benefits of Engineering Economy in Construction Management Curriculum

M. Affan Badar, Ph.D.
Applied Engineering & Technology Management Dept., Indiana State University, Terre Haute, IN, USA
M.Affan.Badar@indstate.edu

Gazan Bozai, Ph.D.
Construction Management Department, East Carolina University, Greenville, NC, USA
bozaig@ecu.edu

Abstract
Construction in the 21st century is characterized by a new set of challenges, options, and expectations from owners and clients. As we move into a new era of globalization, awareness about sustainability and scarcity of resources has been instrumental in devising and experimenting with newer models of project delivery. Concepts such as Public-Private-Partnerships (PPP) and Build-Operate-Transfer (BOT) are being entertained at different levels and seem to gain popularity in certain parts of the world. Since construction projects are always capital intensive and take significant time from inception to delivery, project delays are a common cause of concern. This paper addresses the importance of emphasizing teaching engineering economy in the Construction Management (CM) curriculum and takes a position that the future CM professionals should have the exposure to sound economic principles and concepts. In addition, they must possess the ability to apply those concepts in the project planning and execution phase to minimize the delay and maximize the return on investments. The CM curriculum of various ASC member schools has been analyzed and discussed in the context of ACCE accreditation requirements. It is anticipated that a firm grounding in time-value of money and engineering economy would act as a critical competency in exercising control towards project delays.

Keywords
Engineering economy, public private partnerships (PPP), return on investment, construction management curriculum

1. Introduction

The genre of engineering economics instruction is as diverse and dynamic as the environment to which the science is applied. It is in fact a core developmental course of study that is necessary to facilitate the complete and thorough education of students in technical disciplines in their preparation for professional activities (Alberts et al., 2005). Regardless of the discipline each technical solution has economic consequences in terms of costs and savings (Hartman, 2007). Construction Management (CM) graduates work on construction projects, which are capital intensive and have far reaching societal impact. They are called upon to participate in a variety of economic decisions ranging from choosing the best project from a set of feasible alternatives, through project planning, to execution. These decisions are called engineering economic decisions (Park, 2011; Newnan et al., 2011). Construction alternatives are

generally compared in terms of initial investment required, return on investment, and cash flow profile (Eschenbach, 2003; White et al., 1998). Cash flow profiles differ among several alternatives in terms of the cash flow amounts and their timing. Small construction projects get completed in months but large projects take years in completion, and majority of construction projects fail to achieve the objective of the schedule (Mulholland and Christian, 1999). Thus, in order to make a good economic decision, time value of money needs to be considered (Badiru and Omitaomu, 2007).

2. Construction Management and Engineering Economy

Although construction management as a profession can trace its origin to the early era of master builders, it was not until after World War II that it found its humble beginning as an academic discipline taught at the college/university level in USA (Bozai, 2010a). As any other profession, it has gone through various stages of growth and adaptation based on societal needs and broader environmental and resource constraints. Construction by nature is complex as it deals with a great number of variables and unknown elements. Since the control of design and execution/construction for a project seldom lies with the same entity, this tends to add a new dimension of "step-childing" the project. This saga often unfolds in the form of hotly contested disputes amongst the related entities, claims, change-orders, delays and cost over-runs for the project. The economic challenges have forced the need for a new mindset, which calls for greater collaboration between public and private sectors to address the facilities and infrastructure needs of the society. This has given rise to new modalities of financing as well as the need for the assessment of economic viability of proposed alternatives.

In the wake of new concepts/practices (Sadka, 2007) such as Private Public Partnerships (PPP) and Built/Operate/Transfer (BOT), it is believed that Construction Management (CM) professionals are expected to demonstrate proficiency in economic analysis competency. Not only would this competency position them to play their role effectively on the new frontiers of PPP, but it would also help them control and address the issue of project delays as they would be more attuned to understand the time value of money. The objective of this study is to assess if engineering economy is being covered to the desired level in the academic preparation of CM graduates at US Universities. It further corroborates that the desired attributes needed to perform economic analysis would only be developed if engineering economy is emphasized in the undergraduate curriculum for CM degree programs at the US universities.

3. Accreditation Guidelines

The American Council for Construction Education (ACCE) is the accrediting body for CM programs in USA. The curriculum requirements stated in the accreditation standards provide a certain degree of flexibility and discretion to the institutions in developing courses as long as it meets the stated general criteria. The ACCE standards (ACCE, 2010) state:
"The curriculum should be designed to accommodate continually expanding requirements of the profession, advancements in knowledge, and the contributions of related disciplines. Programs seeking accreditation should strive to provide offerings that exceed the ACCE standards and criteria for accreditation."

The standards require a total of 120 semester (180 quarter) hours for a Baccalaureate degree in Construction Management. The total hours are further divided into six categories as shown in Table 1. It may be noted that the category "Business and Management" is assigned a minimum of 18 semester (27 quarter) hours. ACCE standards further state:
"*This category involves fundamental courses to provide a foundation for contemporary business practices appropriate to applications in construction. No specific number of semester/quarter hours/core*

subject are required, however, eighteen semester (twenty-seven quarter) hours are required in this category."

Table 1. ACCE Curriculum Categories and Minimum Hours Requirement

Curriculum Categories	Minimum Academic Credit
General Education	15 semester (22 quarter) hours
Mathematics and Science	15 semester (22 quarter) hours
Business and Management	18 semester (27 quarter) hours
Construction Science	20 semester (30 quarter) hours
Construction	20 semester (30 quarter) hours

In the category of Business and Management, as a general guideline, four core subject matters are listed. They are Economics, Principles of Management, Accounting, and Business Law. There is no specific requirement as to the number of semester (or quarter) hours for these four areas. The only requirement is that the total must be a minimum of 18 semester (27 quarter) hours.

4. Survey of CM Programs at US Universities

A survey of 129 member schools of Associated Schools of Construction (ASC) was undertaken at East Carolina University to identify how many CM programs offer a course in engineering economy as part of requirement for the undergraduate degree in Construction Management. The survey indicated that only 17 out of 129 universities (which constitutes13%) teach engineering economy in the CM curriculum (Bozai, 2010b). It is evident that a great majority of CM professionals do not receive the academic training and would have very little mastery, if any, in the subject of engineering economy. On the professional frontier, this translates to not being able to demonstrate a higher level of understanding to comprehend, analyze, and perform economic analysis for different project alternatives in complex situations.

5. Private Public Partnerships – The New Frontiers

Public-private partnerships (PPP) were initiated in the United Kingdom in the early 1980s (Sadka, 2007). The concept of PPP was born out of necessity during the Thatcher era when UK was experiencing a struggling economy. The concept has since then gradually spread all over the world. It was conceived as a smart vehicle to put the wealth and resources of private sector for the enhancement of socio-economic status of nations. On the contrary at times, PPP initiatives are viewed by some as a way to mask inadequacy and deficit in public funding (Sadka, 2007).

The last three decades have witnessed a gradual awareness that there has to be a "win-win" mindset and that government should not be viewed as solely responsible for undertaking the development of long-term infrastructure projects. The PPP undertakings have covered transportation infrastructures such as roads, bridges, tunnels, above and underground rail, air and sea ports; water and sewage infrastructures; power generation and energy infrastructure; prisons; hospitals; government office buildings and other facilities.

It may be noted that the projects that are best suited for PPP framework are ones which are characterized as capital intensive with complex cost recovery and return on investment algorithms. At times due to the scope, scale and complexity of projects it is not economically feasible for any single entity to undertake the entire risk or secure bonding in which case it is quite common to forge a joint venture. Projects of this scope, size and level of governance and complexity command a mastery of economic analysis, which can only be amassed through formal academic preparation.

6. Benefits of Teaching Engineering Economy

The competencies developed in the domain of engineering economy are categorized as follows:

- Time value of money
- Concepts of bond, capital investment, capital recovery, and return on investment
- Benefit-cost ratio analysis
- Assessing the relative worth of different projects or project alternatives and decision-making
- Sensitivity and breakeven analysis
- Optimization
- Mathematical modeling

As mentioned earlier, construction projects are characterized by uncertainty, greater variability (as multiple parties are involved), cost escalation, and high number of probabilistic outcomes. Most often these result in delays. In order to understand and address these issues, CM graduates have to know more than the cost estimation. The above listed competencies seem to offer the right set of skills to address the chronic issue of delay and cost overruns.

7. Summary

Construction industry in general and construction management as a profession would be expected to play a higher role and respond to a higher calling of being a good steward of resources while laying the foundation for a sustainable environment for the current and future generations. However, for an industry plagued with chronic ailments of project delays and cost overruns this is a tall order by any measures. The tough geo-economic climate that unfolded in the first decade of twenty-first century has for the first time since the great depression of 1930s brought an onslaught of unprecedented economic challenges. These challenges have driven the industry towards finding innovative and cost-effective solutions for the infrastructure needs of a growing population. In order to successfully address the growing needs it is imperative that higher order decision-making tools be employed. As academia serves as the farming ground for the cultivation of future generation of professionals, it is paramount that a serious re-engineering of curricula be undertaken that emphasizes a component of engineering economy. Addressing this would simply be responsive and meeting the expectations of society at large as well as falls within the mandate of accreditation standards.

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