Integrating delivery of core knowledge and generic skills for an undergraduate Construction Management course

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Structured abstract

CONTEXT
In recent years, many industries have been complaining that engineering graduates do not possess the skills required to compete in the global economy. Academicians feel it is their responsibility to impart education to create graduates for 'tomorrow' and not graduates for 'today' as desired by industries. However, the challenge is to strike a balance between core competency and other generic skills so as to increase employability of the graduating engineer. With growing knowledge in each specialization, finding space in already cramped program for these additional courses is very difficult. However, universities have to develop curricula and teaching–learning systems by maintaining a healthy balance between core knowledge and current needs of generic skills like problem solving, logical reasoning, process orientation, learning ability, communication and programming fundamentals.

India, represented by National Board of Accreditation became a provisional member of the Washington Accord in the year 2007. It subsequently designed outcome based accreditation process for implementation from the year 2013. This has necessitated Indian Universities to design their programs to achieve the intended outcomes, defined as graduate attributes which include generic skills.

PURPOSE
This paper provides details of a teaching-learning scheme being implemented for Construction Management course of Civil Engineering undergraduate programme in an autonomous Institute affiliated to an Indian university. The scheme identifies clearly how the knowledge and skills are being imparted through each topic discussed and each assignment provided. It also includes an evaluation process which will help to assess the levels of core knowledge of the subject and also skills that are imparted.

APPROACH
Reports of National Knowledge Commission (2008), US National Academy of Engineers (2004) and American Society of Civil Engineers (2008) have been studied to identify the attributes expected of an engineering professional. A course delivery system has been designed and developed to help develop these attributes. An evaluation scheme is also designed to check levels of the attributes developed.

DISCUSSION
The proposed course delivery system is likely to provide much desired benefit of developing the generic skills while providing core knowledge. Subsequent to evaluation of outcomes of this experiment, the scheme shall be further revised which shall serve as a model for such integrated delivery systems. Teaching-learning scheme of the entire program needs to be designed to integrate various generic skills to be imparted through courses at various levels during entire program duration. This way student will acquire the skills and also develop acumen to apply these skills in the professional work environment.

KEYWORDS
Teaching-learning system, Integration of core knowledge and generic skills, Construction management

Background

In recent years, many industries have been complaining that engineering graduates do not possess adequate skills to compete in the global economy (Childs and Gibson, 2010). Arguments made in a recent Industry Institute Interaction workshop conducted by All India Council for Technical Education and Confederation of Indian Industries clearly indicates that academicians think that it is their responsibility to impart education to create graduates for 'tomorrow' and not graduates for 'today' as desired by industries. Academicians mainly focus on delivery of technical knowledge. The challenge before today's academic world is to strike a balance between core competency and generic skills to increase employability of the graduating engineer.

The world's top universities and institutes have been experimenting to integrate generic skills with delivery of core knowledge with their learning oriented initiatives. Dion and Bower (2007) have presented an integrated framework for an undergraduate Site Engineering program to provide ABET recommended outcomes over four year period. Schmidt et al (2003) and Davis et al (2012) have shown how they integrated generic skills like teamwork, professional responsibility etc. through project work.

Academic community in India has also recognized the need of imparting generic skills as required in the professional world. Prof. R. Natarajan, then Chairman of All India Council For Technical Education presented (2002) findings of a SWOT analysis of a traditional engineer, in which he listed following weaknesses of a graduate engineer; inability to work in a team, inter-disciplinary knowledge, practical orientation, commercial orientation, introspective nature, modesty, oral and written communication skills, integrative skills, ability to employ information technology, obsolescence, inter-personal skills and public perception and recognition.

National Board of Accreditation (NBA), official Indian agency for accreditation of engineering and technical education programmes, became a provisional member of the Washington Accord (WA) in the year 2007. Subsequently, NBA released documents (2013) for accreditation process in which it has defined graduate attributes that also include the generic skills. NBA has made it mandatory that the program objectives of any program must be consistent with the NBA's graduate attributes.

In light of the above developments, Indian universities and institutes have started developing curricula and designing teaching-learning-assessment methods to meet the outcome based criteria for accreditation. The new curricula are designed to maintain a healthy balance between core knowledge and current needs of generic skills. Thus there is a need to develop teaching-learning and evaluation schemes which will seamlessly develop generic skills and attitudes along with the discipline specific knowledge, skills and attitudes.

Fink et.al. (2005) have recommended that "we need to continue doing research on what it takes to make particular forms of teaching effective – in particular situations, with particular students, with different kind of subject matter, etc." In line with this, an experiment of integrating delivery of core knowledge and generic skills in Indian environment is conducted.

Purpose

Considering the above, on an experimental basis, a teaching-learning and evaluation scheme is designed and is being implemented for a course of Civil Engineering undergraduate program. The course is offered at final year level in an Autonomous Institute affiliated to an Indian University. The scheme identifies clearly how the knowledge and skills are being imparted through each topic and assignment. The scheme includes evaluation processes which help to assess the levels to which core knowledge of the subject and generic skills have been acquired.

Graduate attributes

WA is an agreement among accrediting bodies in different countries, which would lead to mutual recognition of engineering education qualifications and accreditation of engineering programmes. The accord mentions that the purpose of engineering education is "to build knowledge, skill and attitudes to enable the graduate to proceed to training and experience that will develop the competencies required for independent practice in an engineering role" (Hanrahan, 2011). To ascertain that this purpose is achieved, the signatories of WA have outlined twelve Graduate Attributes and Professional Competencies (GA&PC) for engineers. An accredited undergraduate engineering programme shall provide Graduate Attributes (GA), a set of assessable outcomes that indicate the graduate's potential to acquire competence to practice at appropriate level. Further training and experience shall provide an opportunity to the engineer to meet a professional competency (PC). The twelve GA&PC are grouped into four classes, knowledge oriented, problem solving skill group, skill oriented group and, attitude oriented group as shown in Table 1.

Table 1: Classification of GA (Hanrahan, 2011)

Knowledge oriented group	**Skill oriented group**
1. Using engineering knowledge	5. Modern tool usage 9. Individual & team work 10. Communication 11. Project/engineering management
Problem solving skill group	**Attitude oriented group**
2. Problem analysis 3. Design/development of solutions 4. Investigations	6. Engineer in society 7. Environment & sustainability 8. Ethics 12. Lifelong learning

Similar attributes and/or competencies have also been defined by the US National Academy of Engineers (2004), American accrediting agency, ABET (2004) and Australian accrediting agency, Engineers Australia (2005), National Knowledge Commission (2008) and American Society of Civil Engineers (2008). The graduate attributes defined by NBA are also on similar lines of WA.

If such attributes are to be developed during the four year graduate programme, the entire curriculum needs to be designed to indicate the learning outcomes of each course being studied by the student. Many western universities have already developed such curricula and conducted surveys to show the benefits of the same (Fink et. al., 2005). The conventional method of providing the generic skills through additional courses has not met expectations of the Industry. Hence, it is strongly felt that generic skills can also be included in the learning outcomes of individual core courses. In the course evaluation a reasonable weightage can be given to the achievement of generic skills. This will make the delivery more effective.

Taxonomy for the current study

The cognitive domain of educational activities is organized into six different hierarchical levels; remembering, understanding, applying, analysing, evaluating and creating (Anderson et. al., 2001). Krathwohl (2002) stressed the need of presenting learning outcomes in two dimensions, subject matter content and what is to be done with that content, which can be done using the revised taxonomy.

Rugarcia et. al. (2000) have described desired graduate profile in terms of Knowledge-Skills-Attitude (K-S-A). Knowledge is the facts the graduates know and concepts they understand. Skills are the ones they use in managing and applying their knowledge and attitudes are the ones that dictate the goals towards which their skills and knowledge will be directed.

The terminology used in above references is widely accepted and same is used to design the integrated scheme for this study.

The Construction Management course

A mandatory course on 'Construction Management' at the final year of Civil Engineering undergraduate programme is selected for the demonstration of proposed approach for possible integration of delivery of core knowledge and generic skills. The course is a taught course requiring 40 one hour lecture sessions. In the previous years the course was taught and evaluated considering only the discipline specific knowledge and skills.

Learning outcomes for Construction Management

For the proposed experimentation, the learning outcomes for the course of 'Construction Management 'are defined separately as discipline specific and generic. Discipline specific outcomes are defined in terms of K-S-A (Refer Table 2).

Table 2: Discipline specific Learning outcomes

Discipline specific Knowledge
DK 1. Be able to recall historical developments regarding management and its functions DK 2. Be able to relate contributions of Taylor, Mayo, Fayol, Gantt and Gilbreth DK 3. Be able to state and describe life cycle of project, involved agencies and their roles DK 4. Be able to explain plan development process DK 5. Be able to demonstrate use of planning, scheduling and monitoring tools DK 6. Be able to discuss monitoring and control process DK 7. Be able to recognize the environment in which construction industry operates DK 8. Be able to recognize complexities of management issues of mega projects
Discipline specific Skills
DS 1. Given: list of activities to perform and logic for sequencing, Able to: prepare a network and analyse the same DS 2. Given: a plan and resource constraints, Able to: Resolve resource conflict and develop a schedule DS 3. Given: Utility data for project activities Able to: Develop a schedule considering time cost trade-off DS 4. Given: Project activities and logic Able to: use of any open source computer software to develop network
Discipline specific Attitudes
DA 1. Be able to recognize ethical responsibility DA 2. Be able to recognize the need for lifelong learning DA 3. Be able to recognize and appraise relevance of civil engineering activity to the society

Table 3 shows level of achievement expected in each of the topics covered using Krathwohl's (2002) revised taxonomy. However, as per Krathwohl's suggestion, boundary for the highest cognitive process dimension for each topic is relaxed to some extent. Civil Engineering Body of Knowledge for 21st century has shown the expected level of achievement for various outcomes through bachelor's degree program (ASCE, 2008). In line with these recommendations, the complex dimensions of 'evaluate' and 'create' which require making judgments and forming a novel product are not included in the scope of the Construction Management course. The expected level of achievement in each of the eight topics of the course is based on the learning outcomes as defined in Table 2.

Table 3: Matrix showing expected level of achievement in various topics

Topic / Level of achievement		Discipline specific knowledge (Table 2)	Discipline specific skills (Table 2)	Remember	Understand	Apply	Analyse	Evaluate	Create
1	Management	DK1,DK2		✓	✓				
2	Construction projects	DK3,DK8,Dk7		✓	✓				
3	Construction project planning	DK4, DK5		✓	✓				
4	Techniques of planning	DK5	DS1,DS4	✓	✓	✓	✓		
5	Resource Scheduling	DK5	DS2	✓	✓	✓	✓		
6	PERT	DK5		✓	✓	✓			
7	Construction costs	DK5, DK6	DS3	✓	✓	✓			
8	Monitoring & control	DK6, DK8		✓	✓	✓			

For developing their attitudes (DA1, DA2 and DA3) and sensitizing them for ethical thinking and responsibility towards society, specifically designed problems are posed and discussed in the class.

Even though various attempts are made by many researchers to define generic skills (Hermon and McCartan, 2010, Majumdar, 2004, Greatbatch and Lewis, 2007), a specific and standardised list is not available. Based on these sources, a list of generic skills and attitudes which can be addressed during the delivery of the Construction Management course is compiled (Refer Table 4).

Delivery scheme

Literature regarding delivery and assessment methods suggested by various researchers (Angelo and Cross, 1993, Andersson and Andersson, 2012, Mead and Bennett, 2009) has been studied before finalising methods for incorporation in the scheme of this study.
The eight major topics to be covered in the course of 'Construction Management' have been divided into subtopics. As an example, Table 5 shows the session-wise outline of subtopics to be covered in the topic 'Construction project planning'. The table also indicates target learning outcome of each session.

Table 4: Learning outcomes (Generic skills and attitudes)

Generic Skills
GS 1. Be able to communicate orally and in writing GS 2. Be able to identify and interpret problem GS 3. Be able to demonstrate analytical ability and numeracy GS 4. Be able to demonstrate checking skill GS 5. Be able to organize, plan and present own work GS 6. Be able to learn and use a computer software
Generic Attitude
GA 1. Be able to demonstrate self-planning attitude GA 2. Be able to show leadership potential GA 3. Be able to contribute to team assignment

Table 5: Session wise outline for a topic – 'Construction project planning'

Session No	Sub-topic	Delivery method	Learning outcomes
1	Process of development of plans and schedules	Lecture	DK4
2	Level of detail, Role of client and contractor	Lecture	DK4, DK5
3	Pre-tender planning, Pre-construction planning, Detailed construction planning	Lecture	DK4
4	Work break-down structure	Case study, Lecture	DK4
5	Activity lists, Assessment of work content, Methods statement	Reading assignment, Discussion	DK4
6	Estimating durations, Sequence of activities, Prioritization	Lecture, Demonstration	DK4

The main delivery method is lecture. However it is not a monologue, but involves continuous interaction which encourages active learning. Other methods like reading assignment, demonstration, case study, tutorial and simulation are also used for specific topics where it is felt that their use will make the learning more effective.

It is strongly felt that learning could be effective if reading assignments (from text book / reference book / online material) are given to the students and class room discussions are held subsequently. However, earlier experience of the author indicates that for a class of more than 70 students even if 15-20 students fail to do the prior reading, the discussion is not effective. Hence, this method is planned for only a couple of topics. For example, to understand concept of 'Methods statement', a sub-topic, it is necessary to read statements for a couple of construction activities. As the students have learnt construction techniques under a different course in the previous year, it is not difficult for them to understand the contents. The prior reading of method statement shall provide them a level of confidence as to how to write it and which aspects need to be taken into consideration while preparing it.

For the topics (Sr No 4,5 and 6 of Table 3) involving diagramming and numerical analysis, demonstration of the entire process is done. Tutorial sessions are then conducted to help the students at individual level to acquire the diagramming and analytical skills. Individual counselling in such sessions helps them develop generic skills like analysis, checking, and numeracy. The principles of 'scaffolding' using strategies like 'tap into prior knowledge', 'give time to talk', 'pause-ask questions', 'pause-review' are adopted to help the students wherever and whenever needed. For a topic like 'work breakdown structure (WBS)', students are asked to read a case study. Their attention is brought to various aspects of WBS through a check list provided at the end of case study. Prior reading of the case and pondering provides much better understanding of the concept of WBS which is very pertinent in case of complex and mega projects.

As the course is being taught at final year level, it is assumed that students have acquired the generic skills as mentioned in Table 4 to a certain level in the previous years of study. However further development of these skills is envisaged during the delivery of this course. Table 6 shows the topics under which the generic skills mentioned in Table 4 are being developed.

Table 6: Generic skills that would be imparted under various topics

	Generic Skills	Communication (GS1)	Problem solving (GS2)	Analytical (GS 3)	Numeracy (GS 3)	Checking (GS 4)	Self-planning (GS 5, GA1)	Computer (GS6)	Teamwork (GA3)	Leadership (GA 2)
1	Management	✓								
2	Construction projects	✓								
3	Construction project planning	✓				✓				
4	Techniques of planning		✓	✓	✓			✓	✓	
5	Resource Scheduling		✓	✓				✓		
6	PERT			✓	✓					
7	Construction costs		✓							
8	Monitoring & control	✓		✓			✓		✓	✓

To make the students aware of the complexities of real world situations and also the ever dynamic environment of construction activity a simulation game is planned. We have used simulation in the past and though time consuming; it has been a very effective delivery method. The simulation involves participating teams (a group of 4 to 6 students) to perform the role of contracting agency which involves bidding, planning for a project, monitoring performance, applying control measures if there are deviations, and communicating with the virtual client (game administrator). The entire exercise is simulated for 3-4 bidding cycles over a period 8 to 10 quarters. All teams get at least one project to complete. The 'role play' technique is also used by assigning different responsibilities to the students in different cycles. In addition to developing discipline specific attitudes, the entire exercise also helps to develop the generic skills of communication, self-planning and teamwork.

Assessment scheme

As per the general scheme of assessment for the undergraduate programme, the course evaluation has three components; in-semester tests (one mid semester test and two class tests evenly spaced out over the entire semester), teacher assessment and end semester examination having evaluation weightages of these three components as 20:20:60. Considering the fact that unless the generic skills are part of the assessment plan, the students are not likely to take any efforts to improve their skills, these are evaluated as part of the teacher assessment.

The question papers of in-semester tests and end semester examination are carefully drafted to include questions to assess the achievement of expected level of knowledge as mentioned in Table 3. Continuous assessment is being done to monitor the level of learning and help students to improve on their performance as the teaching progresses. Students are expected to solve eight problems; targeted at discipline specific skills and submit eight assignments; targeted at discipline specific knowledge. All the submissions and the in-semester tests are separately assessed for generic skills demonstrated. For example, an assignment is valued for 10 marks based on its discipline specific knowledge. Same assignment is also valued for each relevant generic skill on a five point Likert scale. Assessed submissions are returned to the students within a week from the date of submission. The expected form and content of the submission is discussed in class. Students who score consistently very poor on generic skills assessment, are advised by the instructor.

For assessment of attitudes one has to rely on inference. Discussion with individuals on specific topics (e.g. to assess ethical responsibility) and observation of their behaviour (e.g.

to assess leadership potential) is done. Students may be manipulative and it may be difficult to do unbiased objective assessment of an individual. Hence though the assessment is done using a psychometric scale, same is not considered for course evaluation. Peer evaluation is also planned for certain aspects like teamwork, leadership potential and self-planning attitude. Students who do not indicate positive attitude shall be counselled. Documentation of the same is maintained to check the improvement over time.

In a couple of sessions, students are asked to write brief statements that recall, summarize, question, connect and comment on meaningful points from previous classes indicating their level of confidence in mastering the course material. A course-related 'self-confidence survey' shall be conducted at the end of delivery period. This will also incorporate a 'checklist survey' to indicate their knowledge, skills and interest in various course topics. Student feedback about value of an assignment or examination and its contribution to their learning value shall also be collected. These surveys will indicate what the students were expected to learn from the course and to which level their expectations were met. Though these surveys largely depend on 'perception' of the student, overall output can be used for further improvement in delivery and assessment methods.

Discussion and future work

The course delivery and assessment system is likely to provide much desired benefits of developing the skills while providing core knowledge. The surveys conducted at the end of delivery and assessment period may indicate level of effectiveness of such integrated system. Based on these results of surveys, further revision in the scheme for effective learning of both knowledge and generic skills to the desired levels can be done. Few more such experiments by different instructors with different courses will provide how best such integration can be done in a more systematic way in Indian academic environment. The scheme once developed and incorporated into entire four year curriculum may bring in 'learning' oriented cultural change from the present 'spoon feeding and rote learning' culture. This will help students to acquire the discipline specific and generic knowledge, skills and attitudes and will also develop acumen to perform better in their area of work.

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