DESIGN CURRICULUM IN ENGINEERING EDUCATION : SOME ISSUES

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The design is most important component of engineering field. There has been phenomenal progress in the design gained by many researchers. But this progress has been confined to specialized areas such as computer science and engineering. In this article, we attempt to present some issues involved with design component of engineering. We have tried to generalize the aspects of design curriculum. A large literature is available on the importance of design aspects of specialised field (3, 4, 5).

Introduction

Amongst various components of engineering, we can remark 'design' as most important component and urge that the effective instructional methodologies must be evolved to impart full knowledge of design to the students. We suggest that a pure course on design methodologies must be introduced in all disciplines of the engneering field. We feel that without proper design, a potential engineer is not competent in attacking the real world problems.

A basic design methodology is needed commonly to all areas of engineering except for some unique aspects which may be applicable to one or few disciplines(3). An engineering student may take long time to take full responsibility of designing a major system. This long time learning process can be shortened by inclusion of a proper curriculum of 'design'. In this article, we report some salient features of the design activity, its importance in engineering education and the requirements to properly place the 'design' in engineering curricula.

Basics of Design

The design component of education distinguishes an engineer from a scientist. In the field of technology, the design has been considered as the traditional province of an engineer. According

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to the definition given in (1), "The engineering design is the process of devising a system, component or a process to meet desired objectives. It is often a decision making process (iterative in nature) in which the laws of basic science and mathematics are applied to convert the resources optimally to meet a stated objective. The establishment of objectves and criteria, synthesis and analysis, construction and testing and finally evaluation are fundamental elements to the design process".

To create a model design, the engineer must have an indepth understanding of mathematical and physical relationships needed to solve a problem. An engineer must consider a number of possibilities to a design problem and suggest the best which meets the design criteria. He must consider social and economical aspects in addition to the technical ones. A high degree of technical competence and the deep knowledge of appropriate analytical methods make a good engineering designer. To have all these qualities in an engineer, the curriculum of the 'design' course must be designed while keeping the following aspects in consideration (2) :

(i) Student's creativity and motivation

(ii) Exposure to open-ended problems

(iii) Formulation and specification techniques

(iv) Possibilities for alternate solutions

(v) Consistency and feasibility

(vi) Systems specifications at predesign level, intermediate level and implementation level

(vii) Technical and documentation standards

(viii) State-of-the-art requirements

In addition to these technical aspects, a variety of realistic factors must also be included during the preparation of the curriculum for 'design' course. These include economic factors, safety factors, reliability factors, aesthetic and ethical factors and social factors.

The main steps of design process (2) are

(a) Problem definition and description

(b) Formal specifications

(c) Conditions, limits and constraints, if any

(d) Preliminary design : List number of possible solutions

(e) Intermediate design : Evaluate the all possible preliminary design alternatives

(f) Prototype Design : Realize the 'best' alternative with appropriate standards

(g) Verification and acceptance : Test

the design to satisfy the given specifications within a given tolerance.

Types of Design

The design methodologies can be classified according to levels. One of the most important component of design process is the transition from requirements to final design. To address designers and developers, some baselines must be formulated. These baselines are to increase the reliability and productivity of the design output.

Mainly, two levels for design can be adopted : (a) module design (b) task design.

(a) **Module design :**

A module is a unit of engineering work in designing and developing procedures to accomplish a required transformation. Given no constraints on time, the procedures satisfying the accuracy and precision are selected for use. A module design can go in two phases : preliminary and detailed with a review process in between. The preliminary phase is accomplished by partitioning the required work into modules. The required design data is partitioned into logical components. In the detailed design, a hierarchy of modules is organised. The designer estimates sizing and time requirements of procedures selected in preliminary design phases.

(b) **Task design :**

In this level of design, the logical design must be transformed into the physical design using available data formulation techniques. This approach is structured and reduces more number of iteration in the design process as a whole. The iteration process is confined only at task level. The processing requirements include the data constraints and conditions under which the specifications are to be met. Advantage of the task design is that the larger problem gets converted into smaller problems which require reduced efforts and are convenient to handle.

New Trends in Design :

There has been a phenomenal progress in the engineering design approaches. Earlier methods of design were dependent on data manuals, manual drafting tools and calculators. The new trends in the design of any system include sophisticated tools such as computerised manuals, plotters and design software packages. The design automation is a prospective aspect of the future design problems and particularly, it is going to put everlasting impact in the engineering discipline. Any engineering system is usually organized by means of blocks revealing the overall behaviour of the top-level structures of subsystems. The relationship between the blocks are described and the overall behaviour of the system is then determined. The design process has been largely a human effort and only recently have attempts been made to automate any part of the process. As mentioned earlier, the initial stages of a design activity include problem definition, requirements generation, analysis and various design levels.

In addition to these stages in manual design, the design automation requires the system decomposition. The design automation lets the designer exploit his own creativity more fully by exploring more designs in a comparatively shorter period. The correctness of design is assured by the design automation techniques. The design automation continues to be alternative to the traditional and conventional design methods.

Design Curriculum : A Proposal :

The 'design' has been the most important of the engineering and technology discipline. A pure curriculum on 'design' is essential in the engineering education in all disciplines. Three levels of the design curriculum have been proposed in (3) for a specialised discipline. A similar hierarchy may be adopted in general for all disciplines of engineering. These levels are :

(a) Fundamental level Courses

(b) Intermediate level Courses

(c) Advanced level Courses.

The fundamental 'design' course must typically concentrate upon various common terminologies, approaches and small case studies. Each student at junior level must complete one or two design problems of the moderate difficulty that involve use of data books and manuals. The student must also learn how to refer to tables, charts, standards etc. at this level. Some typical problems in the respective discipline may be taken and designed by students. For mechanical engineering discipline, the example can be design of a small crankshaft. In computer science discipline, the student may design and develop a software for dynamic telephone directory system.

The courses with intermediate level of the design content must introduce more advance principles and techniques. The student must learn to apply the design material to a variety of the realistic problems. The student must be able to demonstrate the conceptual and functional description of the medium-sized projects. The presentation of the designed work and documentation skill should also be included at the intermediate level.

The advance courses in design curricula must involve advanced principles to be applied on realistic large scale system design problems using a group approach. At this level, the concepts of module and task design must be elaborated at deeper details. The extensive use of advanced design tools such as computers, drafting aids etc. must be involved in the advanced course curricula for training and experience purposes. This training must motivate the students to undertake design projects representing realistic challenge of the industries and current technological developments.

Facilities for Design Curriculum :

The design component of engineering at both undergraduate and postgraduate level requires significant commitment of the facilities by the in-

stitution. The lack of facilities for design causes the discouragement to the students, faculty and research scholars. It is therefore essential that proper efforts be made to procure, maintain, update and renew the required resources. Sufficient faculty student interaction, assisting personnel, laboratory training, library resources such as data manuals, references, standards etc. are the favouring factors for better design education. The courses with more design contents must allow frequent and close faculty-student interaction. In order to be acquainted with designers working on similar problems, a selection of technical publications and specification charts must be available.

Computer is playing an important role in the design. The computing facilities with rapid response time and its frequent availability makes the design process productive and effective. A range of software tools such as AutoCAD, VersaCAD, computer-aided instruction (CAI) tools should be made available to support design activity in all disciplines.

Concluding Remarks :

The design must be an important component of engineering education and there should be continuous training in this component throughout the engineering education period of studies. The design must continue to be the major aspect in all branches of engineering. The design education must not be omitted from the curriculum even if it is costly and time consuming activity.

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