Work in Progress - Practical “Know-How” in Engineering: Dissection Labs & Capstone Design

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Abstract - Based on a series of previous studies to identify the design engineering body of knowledge, methods are being sought to effectively implement a “know-how” skill set within the mechanical / automotive / materials engineering curriculum. Aside from acquiring competence in the standard engineering sciences and analytical methods, greater emphasis is being put towards establishing an innate feel for machinery, precision measurements, manufacturing methods, team based project work and a range of professional practice issues. Lack of sufficient exposure to an experiential knowledge base is being overcome through a series of “dissection and rebuild” laboratories plus team projects with shop-intensive content requiring conceptualization, planning, detail design, manufacturing, prototype assembly and testing. The Capstone Design experience is being implemented with a view towards establishing engineering design teams operating within a “virtual company” who report to a management board constituting the diverse interests in a corporation. These include senior engineering, expert consultants, the manufacturing division, finance, marketing and clients.

Index Terms - Capstone, Product design, Dissection, Know-how, Manufacturing, Practicum.

INTRODUCTION

Typical curricula are restricted to engineering math and sciences while the underlying need to acquaint an upcoming mechanical / automotive / materials engineer with industrial and design office experience is being ignored [1]-[3]. The University of Windsor is in the midst of implementing above-mentioned concepts with an eye towards establishing first an optional series of three separate 1 week long “manufacturing & technology camps” attached to co-op work terms and carried out at a nearby Applied Arts and Technology College. St. Clair College’s Ford Center for Excellence in Manufacturing (FCEM), is Canada’s most extensive and modern, a SCAN 32.6M - 9300 m² facility. Additionally, at least one complete and formal laboratory course in manufacturing technology is planned for all engineering students using the same venue. With adequate preparation in the technological aspects, parallel to absorbing the classical theory in chalk and talk lectures, mechanical engineering graduates will become more adept at dealing with the broad ranging skill-sets required by the emerging class of design engineers. These individuals are replacing the once separate specialists staffing manufacturing, product design, drafting, and analysis divisions in companies.

PRODUCT DESIGN MODEL

The mechanical engineering program at the University of Windsor has for a number of years been building towards an engineering practicum delivery that melds these requirements and the wishes of industry partners. The outermost loop (design and production) cannot be properly implemented nor practiced until the student has partially mastered the inner loop (engineering sciences), which in turn is built upon an innermost core (basic sciences).

Changes and additions outside of the usual mechanical engineering curriculum are presented as a template to other institutions wishing to implement similar. The Capstone Design organizational structure and metrics developed within the mechanical program are now being formalized into faculty wide baseline requirements at Windsor.

DESCRIPTION OF WORK

A partial transformation towards these goals has already been achieved. Generating the versatile design engineer requires certain investment and infrastructure changes. Support from industrial partners, government, exploiting synergies between educational institutions, and champions within the university academic hierarchy are necessary elements. At Windsor strong corporate support via DaimlerChrysler [4] - specifically the 3E fund, infrastructure expansion (SSI government / industry fund), cooperation with Saint Clair College, a neighboring institution offering 3-year B. Tech. diplomas, an extensive co-op and internship program, and faculty support for capstone design endeavors all contribute towards the educational profile envisioned.

For example, present curricula and infrastructure for the automotive option includes an introductory mechanical...
dissection lab where 3rd year students are each provided with a 5 HP gasoline engine and assigned their own workbench and cabinet space. In addition to regular textbooks for this and the subsequent capstone design course, they must also acquire basic hand tools and measuring instruments such as digital calipers. Access is given to specialized tools and instrumentation, for example: Vehicle scan tools, engine dynamometer, emissions analyzer, infrared temperature probe, sound meter, optical tachometer, metrology equipment. Students are provided with production engineering drawings of the engine to gain familiarity with GD&T. Requirements are to run and test their unit’s performance, disassemble the engine and its subsystems (eg: carburetor), answer a comprehensive set of questions related to functional requirements and engineering detail of the various components, manufacturing processes, tolerances and materials of construction.

Further, the class visits the production facility and assembly line where their engine was produced prior to commencing engine re-assembly and verification testing. Subsequent to this experience, group projects are selected by the students. These entail the disassembly and repair / rebuilding of specific automotive components. Requirements include photographic documentation and a descriptive text of their findings and steps followed in either poster format and / or instruction manual as deemed appropriate. Typical projects range among (but are not limited to) rebuilding worn auto engines, transmissions, suspension - steering - brakes assembly / disassembly manuals. This laboratory intensive portion of the course, worth 50%, is given alongside the normal lecture component describing the operating theory of vehicular systems.

A subsequent 2-semester final year capstone design course capitalizes on such experience. Year 3 students having gained sufficient exposure interact and prepare to take over the reigns of 4th year student’s international design competition efforts. Typically, Formula SAE®, Mini-Baja®, Supermileage® and similar high profile organized events are worked on throughout the intervening co-op term on evenings and weekends. A small group of faculty, technologist and administrative officer provide technical support and organization for fundraising. Teams are hand picked by the faculty advisors after sifting through a round of competitive applications where the students describe their skill-sets, motivation and background. Selection is loosely based on the homogeneous interest - heterogeneous GPA method described by Dutson [5]. Teams constituting the most ambitious projects are carefully screened to avoid anyone falling in the bottom third of the GPA rankings for reasons of reliable commitment and balancing of their academic workload. Group size is restricted to a manageable 6-10 core members depending on project complexity. Leadership is split between a technical head and team manager for the larger projects. Members are tasked with the design / engineer / build responsibilities for specific sub-assemblies and manage non-credit helpers drawn from the lower years - when such help is forthcoming. Increasingly, especially for high-profile projects, such helpers present themselves from the technical college through to the 3rd year level mainly by word of mouth. Infrastructure includes a design office and project assembly hall with subdivided work areas for the groups. Regular design meetings follow with the faculty / technologists / administrative officer. They play dual roles as company management and technical experts.

DISCUSSION AND OBSERVATIONS

Association with the local technical college is still in relative infancy but growing rapidly. Adequate manufacturing and project assembly space dedicated to student use comes only with large capital investment - lessened somewhat by resource sharing. The expanding circle from basic sciences, to engineering sciences and finally the design and manufacturing engineering process as a whole is best approached in stages. Early exposure to the industrial environment via co-op terms and internships, followed by increasingly complex design projects with hands-on shop experience is desirable. The manufacture and execution of such designs is a very valuable experience for young engineers. It unequivocally teaches the necessary adequacy for functionality and the inherent value of simplicity for production. Dissection and reassembly of complex mechanical devices, while acquiring an understanding of the design tradeoffs made, is the forerunner to tackling much larger and complex design-build endeavors that the Capstone experience entails. Acquiring excellent in house facilities, dedicated technical staff involvement and active faculty guidance / mentoring leads to success.

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REFERENCES