Comparison of mechanical engineering curricula containing internships between California State University Northridge and Ming Chi University of Technology

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ABSTRACT: Learning by doing during an internship is not new in undergraduate education, but is a fundamental element in gaining successful experiential learning. Students seek academic course credit for their internship to meet graduation requirements. The curricula of mechanical engineering at California State University Northridge (CSUN) and Ming Chi University of Technology (MCUT) in Taiwan differ in the proportions of theory and application courses they contain. A revision and comparison of the undergraduate mechanical engineering curricula of the two universities has been undertaken for this article. The accredited programmes of the Accreditation Board for Engineering and Technology (ABET) that were followed, induced different achieved abilities of students. The comparison of the curricula in the concerned courses is presented. This research indicates that the study of manufacturing processes is weighted more highly at CSUN, because it comprises six credits courses within two semesters. The internship at MCUT is a fundamental course for deriving the practical training during the Bachelor degree. Oral communication and technical writing courses in the USA help students to meet the requirements for employment. The comparison of the mechanical engineering curriculum between the USA and Taiwan could lead to a reshaping of course arrangements.

Keywords: Comparative education, internship, curriculum, mechanical engineering

INTRODUCTION

A successful transition from college to the world of work increasingly requires relevant work experience. As job market competition rises amongst graduating students. Huntingdon College is responding by encouraging, facilitating, and overseeing internship experiences that enhance self-awareness and provide opportunities to develop occupational skill-sets and professional networks. Internships not only help students to understand the world of work better, and how they might fit into that world, but it also allows them to build the foundation for a marketable work history. Another well-known benefit of internships is that they lead to many more full-time employment offers after graduation. It is an important but difficult issue to understand the structure and coverage of tertiary education programmes.

Recently, there has been an increased emphasis on monitoring the structure and coverage of tertiary education programmes, and on making the results more widely available. Baker indicated that the curricula should be compared in terms of curriculum characteristics including entrance requirements, accreditation, length of programme, instructional methods, scholastic standards, tuition costs, general education requirements and requirements in technical courses [1]. An examination of previous comparisons of other colleges in this country and/or in other countries, shows that different countries have their own styles.

All internships have the general goal of having students apply their learning. Academic internships, which are characterised by being linked to the undergraduate curriculum in one or more ways, have more specific learning goals and broader outcomes than just career exploration or learning the basics of professional practice. Non-academic internships for which students do not receive credit are usually limited to work experience for the student; and there are no measurable learning outcomes. Part-time internships offer less time at the work site, and thus, the learning outcomes are limited. Full-time internships (usually defined as thirty-two hours per week) significantly increase the students' learning and enhance intellectual and skill development [2]. Credit-bearing internships are very distinctive, because they share common goals and elements with on-campus study.

One way to test this is to compare the curriculum to a known standard for programmes in the field of mechanical engineering. In recent decades, many institutions monitored their own programmes only informally, and little effort was made to enlighten outsiders. There has been an increased emphasis on monitoring the structure and coverage of tertiary education programmes by outsiders, such as the official agent and the non-government organisation. The Accreditation Board for Engineering and Technology (ABET), one of the non-government organisations, has recently become the

recognised accreditor for college and university programmes in applied science, computing, engineering and technology (http://www.abet.org/mission.html, 2010/08/12).

Table 1 provides a comparison of the freshman mechanical engineering programmes offered at MCUT and CSUN.

Table 1: Freshman courses in mechanical engineering at MCUT and CSUN.

Freshman Year			
ME - MCUT		ME - CSUN	
Course	Credit	Course	Credit
Calculus I, II	6	Calculus I, II	10
Statics	2		
Computer Aided Mechanical Drawing	2	Computer Aided Design	2
General Physics	6	General Physics: - Mechanics & Lab	4
English	6	Freshman Composition	3
		Oral Communications	3
Computational Programme and Practice	1		
Dynamics	3		
Chemistry	3	General Chemistry & Lab.	5
Engineering Thermodynamics	3		
Principles of Electrical Engineering	3		
Practical Machining Workshop Training	1		
Experimental Design and Analysis	1		
Special Project (I)	1		
Precision Measurement and Practice	2		
Chinese	6		
Constitutional Development(H/SS Elec.)	3		
Humanities and Social Sciences(Elec.)	2	Arts & Humanities (LD)	3
		Introduction to Mech. Engr.	2
Total	51	Total	32

Traditionally, the baccalaureate Mechanical Engineering (ME) courses provide the broad skill set required for both entry-level success and long term advancement. The core courses include topics such as thermodynamics, dynamics, fluid mechanics, and automation and control systems. Effective written, oral and graphic communications are practiced throughout the curriculum along with computer literacy.

Students in ME are prepared for a range of technical positions including system design, fabrication, manufacturing, heating, ventilating and air conditioning, and construction. In other words, the baccalaureate students of the ME programme are prepared for professional careers as mechanical engineers, and for graduate study in mechanical engineering or related fields.

Mechanical engineers design and manufacture systems, which convert energy into useful work. Using the laws of nature, along with mathematical analysis, communications and computational skills, students are educated to develop creative solutions for societal needs. As a fundamental engineering discipline, mechanical engineers are sought by virtually every industry and government agency.

Mechanical engineers are employed in areas specialising in design, research and development, manufacturing, production, management, project planning, consulting, testing, quality assurance and technical sales (http://eng.odu.edu /me/2010/07/16). The previous shows that the educational objective and the core ability, as well as the professional career are adequately different. The courses of each department should, therefore, be different for the achieved abilities of student [3].

However, in Taiwan, both the engineering departments and the engineering technology departments in technological universities follow the accredited programme of the Engineering Accreditation Commission (EAC) of ABET. Both the Department of Mechanical Engineering at the Ming Chi University of Technology and the Engineering Department at the Technological University follow the accreditation process of the Technology Accreditation Commission (TAC). This article, thus, reviews the undergraduate curricula of Mechanical Engineering of MCUT and, and then compares these two.

At CSUN, the ME programme is a four-year one for the students enrolled from the community college and Junior College. At the same time at MCUT, there is a programme of ME similar to the CSUN programme. A comparison of the results of the curricula and, then, a description of those curricula, are presented and discussed in this article.

Table 2: Sophomore courses in mechanical engineering at MCUT and CSUN.

Sophomore Year			
ME - MCUT		ME - CSUN	
Course	Credit	Course	Credit
Mechanism Fundamentals	2		
Strength of Materials	3		
Mechanical Elements Design	2	Mechanical Eng. Design	2
Principles of Electronics	3	Electrical & Mag. & Lab	4
Humanities and Social Sciences(Elec.)	2		
Comprehension and Oral in English	2		
		Eng. Statics	3
		Programming for ME	1
History	3		
Materials Science and Engineering	3	Eng. Materials & Lab	4
Mechanical Material Experiments	1		
		Electrical Eng. Fund. & Lab	4
Automatic Control	3		
Special Project (II)(III)	2		
General Physic Experiments	1		
Engineering Mathematics I	3	Applied Diff. Equations	3
		Calculus III	3
ME Elective	15		
Humanities and Social Sciences(Elec.)	2	American Gov	3
		Comp. Cultural Studies (LD)	3
Total	47	Total	30

Table 3: Junior year courses in mechanical engineering at MCUT and CSUN.

Junior Year			
ME - MCUT		ME - CSUN	
Course	Credit	Course	Credit
Internship I, II	20		
		Numerical Analysis Eng. Sys.	2
		Mech. Measurements	2
		Eng. Dynamics	3
		Thermodynamics	3
		Thermal Transfer	3
		Strength of Materials	3
		Social Science	3
		Machine Design	3
		Computer Aided Analysis & Design	3
		Fluid Mechanics	3
		Mechanics Lab.	1
		Eng. Economic Analysis	3
	20		32

INTERNSHIP WITHIN ENGINEERING CURRICULUM

The undergraduate programme is a general mechanical engineering curriculum designed to allow students within the MCUT and Taiwan degree framework to develop the knowledge necessary to begin a career as a mechanical engineering professional, or to begin graduate study in mechanical engineering. Students may credit mechanical engineering courses to meet the requirements of undergraduate degrees; however, those seeking a profession in mechanical engineering are typically working toward a baccalaureate of science degree. Both degrees offered by the University and Technological University, the Taiwan expectations of two years duration are the same as the BS.

At the time of this study, neither the educational objective of the department nor the core abilities of the students prescribed mechanical engineering major requirements were different, and so even for students intending to specialise in mechanical engineering, the programme is constrained only by the general BS requirements. Consequently, this study generally applies to the current situation. The particular way the curriculum is structured into courses reflects the four-year nature of the degree. The course design has been influenced by previously published curricula; courses taught elsewhere and staff expertise. Based on the CSUN Web site, the baccalaureate ME programme provides a strong foundation in energy, motion, materials, fluid power and manufacturing processes. These ME courses are supplemented by courses that provide background in related technical and non-technical topics essential in modern industry.

Graduates take up a variety of positions in areas such as product design/development, process design/development, plant operations, facilities management, quality assurance, field technical service, production supervision, technical sales and research.

In total, the students must complete 148 credit points to meet the graduation requirement of ME at MCUT (http://www.me.mcut.edu.tw/onweb.jsp?webno= 3333332332&plug_page= &dwua=dotweb, 2010/08/12) and at CSUN. As Tables 1 and 2 show, the courses in *Mathematics or Calculus*, *Manufacturing*, *Materials*, *Mechanics*, *Drawing* and *English* are the general service courses and could be considered to be an essential part of the main undergraduate programme. The *Automatic Control* and *Special Project* courses are two courses that must be undertaken in the first year of the MCUT programme.

At CSUN, the *Production Design and Specifications* programme is different from the MCUT programme. In addition, the zero-credit courses, which are compulsory subjects in the MCUT programme are particular to Taiwan. The students at MCUT are Taiwan's frontier students, so MCUT provides an Engineering Mathematics course of six credits. It has been proved that the quality and level of students are not dependent on their majors, but on the whole system and content of the courses, and the knowledge, quality and capacity drawn from that. Thus, the configuration of the course system in the whole teaching is very important. To a certain extent, the course system is the actual reflection of the professional training goal.

Table 4: The fourth year courses in mechanical engineering at MCUT and CSUN.

Senior Year			
ME - MCUT		ME - CSUN	
Course	Credit	Course	Credit
ME Elective	15	Senior Elective	12
Elective	6		
Elective	2	Senior Design in ME I	2
Humanities and Social Sciences(Elec.)	2	Arts & Humanities Elective	3
		Senior Design in ME II	2
Special Project (IV)	1	Mechatronics & Lab	3
Seminar in Profession and Practice	1	Thermal-Fluids Lab	1
Seminar on New Technologies for Smart Living	1	Comp. Cultural Studies Elective	3
Experiments for Mechanical Engineering I, II	2	Systems Dynamics	3
		Internship A, B, C (Elec.)	9
	30		38

In Tables 3 and 4, the course on Intermediate Mechanics of Materials is the same approach to offer the course to the *frontier* students enrolled at MCUT. This is a general service course, and is not considered part of the main undergraduate programme. The most important and hardest point is the joint nature of courses. In many cases, to emphasise the entity of the course configuration, students are required to acquire a quantity of certain volume of information and knowledge, but sometimes they ignore the level and the continuity of the courses, which leads to the situation where the different courses taken by students are disconnected, and the training goal cannot be fulfilled.

COMPARISON OF RESULTS

In order to compare the two curricula, the knowledge units covered by the course were compared. For purposes of comparison, the concern was primarily with lecture hours. In fact, the actual comparison of results is shown in Table 5. Each cell in the table shows a knowledge unit course, such as mechanics and so on. The number of lecture hours identified is shown as the *credit* for each course. The Physics course, worth eight credits, is a fundamental one at CSUN, but it is not offered at MCUT. *Manufacturing Processes* is more important at CSUN, indicated by the six credits courses within two semesters. Fundamental theories such as *Thermodynamics*, *Fluid Mechanics* and *Strength of Materials* were offered at MCUT, while at CSUN, *Heat Power*, *Fluid Power* and *Applied Strength of Materials* were provided. These can be arranged or augmented in many ways to suit the requirements of many different kinds of degree programmes. In fact, knowledge units can even be split across courses. Each knowledge unit is described in the report together with the minimum amount of lecture time necessary for the pre-requisite knowledge units.

Of course, this is reasonable and explicitly allowed for in this analysis, because there seems to be a broad agreement between the ME programmes at MCUT and CSUN. Finally, one should acknowledge that in the Architecture subject area there are a few knowledge units with hours. However, at CSUN the ME programme provides several courses involving *Fundamentals of Speech Communication* and *Mechanical Drawing*, as well as *Production Design and Specifications*, indicating that both oral and graphic communications are important for a mechanical engineer. Furthermore, *Calculus* is seen by CSUN as essential for engineering training rather than *Engineering Mathematics*.

Table 5: The whole courses of mechanical engineering in MCUT and CSUN.

ME - MCUT		ME - CSUN	
Course	Credit	Course	Credit
English	6	Freshman Composition	3
Chinese	6		
Comprehension and Oral in English	2	Oral Communications	3
General Physics	6	General Physics: –Mechanics & Lab	4
General Physic Experiments	1	Phys- Elec. & Mag. & Lab	4
Calculus	6	Calculus I, II	10
		Calculus III	3
Engineering Mathematics I	3	Applied Diff. Equations	3
Chemistry	3	General Chemistry & Lab.	5
Statics	2	Eng. Statics	3
Dynamics	3	Eng. Dynamics	3
Strength of Materials	3	Strength of Materials	3
Engineering Thermodynamics	3	Thermodynamics	3
		Thermal Transfer	3
		Introduction to Mech. Engr.	2
Computer Aided Mechanical Drawing	2	Computer Aided Design	2
		Computer Aided Analysis & Design	3
Computational Programme and Practice	1	Programming for ME	1
		Num. Analysis Eng. Sys.	2
Mechanical Elements Design	2	Mechanical. Eng. Design	2
Mechanism Fundamentals	2	Machine Design	3
Special Project I,II,III, IV	4	Senior Design in ME I II	4
Principles of Electrical Engineering	3	Mechatronics & Lab	3
Principles of Electronics	3		
Materials Science and Engineering	3		
Mechanical Material Experiments	1	Mechanics Lab.	1
Precision Measurement and Practice	2	Mech. Measurements	2
Practical Machining Workshop Training	1		
Automatic Control	3	Systems Dynamics	3
Experimental Design and Analysis	1	Eng. Economic Analysis	3
Experiments for Mechanical Engineering I, II	2	Thermal-Fluids Lab	1
		Fluid Mechanics	3
Humanities and Social Sciences(Elec.)	2	American Gov	3
Humanities and Social Sciences(Elec.)	2	Comp. Cultural Studies (LD)	3
Constitutional Development(H/SS Elec,)	3	Arts & Humanities (LD)	3
Humanities and Social Sciences(Elec.)	2	Arts & Humanities Elective	3
Humanities and Social Sciences(Elec.)	2	Social Science	3
History	3	Comp. Cultural Studies Elective	3
ME Elective	36	Senior Elective	12
Elective	8		
Internship I, II	20	Internship A, B, C (Elec.)	9
Seminar in Profession and Practice	1		
Seminar on New Technologies for Smart Living	1		
Total credits	148	Total credits	136

To a certain extent, this difference is reduced by the importance attached to broad requirements in CSUN baccalaureate degrees. Such requirements are less usual in Taiwan in general, and in particular, there are no such requirements in ABET. The courses to achieve students' core abilities are required by the Curriculum Committee of their department. ABET identifies the procedurally established rule, and never attests the effectiveness of the arrangement. This might suggest that the curriculum of ME could possibly abandon some of the advanced material in favour of greater emphasis on some more basic units. However, the Technological University in Taiwan should make sure that the coverage of the basics is sufficiently good and that the students will benefit more by the provision of the more advanced courses. Many of the graduating students leave the Technological University to begin careers as associate engineers, not as technicians. The Curriculum Committee must structure the programme to support that transition.

A weakness in the Taiwanese system in the MCUT programme is that there is insufficient emphasis on engineering software application. The design process in several courses the ME programme does not provide enough opportunity for students to acquire the necessary skills in this area. There is a similar problem with user-interface design and software reuse – both issues that are now acknowledged as being of great importance to modern software development.

CONCLUSIONS

Internship programme goals will determine which structures are used and at what stages of a student's curriculum. Freshman or sophomore internships may be exploratory in nature and include few project elements. A capstone internship course, like the one required of students in the Human and Organizational Development major at Vanderbilt University, will emphasise cumulative learning. This internship is done in one of the later semesters before graduation and includes a senior project that is assessed for mastery of the content and skills of the major.

Other internships are tied to a specific course topic or to mastering the skills of a profession, such as social work. Education majors often do an internship or practicum, before they do student teaching at the end of their teacher-training curriculum. Traditionally, the baccalaureate mechanical engineering courses provide the broad skill set required for both, entry-level success and long term advancement. In this comparison of the four-year ME programmes at MCUT and CSUN, it could be concluded that *Automatic Control* and *Special Project* are the two courses in the first year, in particular, in MCUT. At CSUN the *Production Design and Specifications* is different from the one at MCUT. Besides, the zero-credit courses, which are compulsory subjects in MCUT, are peculiar to Taiwan.

The students at MCUT are Taiwan’s frontier students, so MCUT provides the *Engineering Mathematics* course of six credits. However, the ME programme does not provide enough opportunity for students to acquire the necessary skills in the package software application within the design process sections of several courses.

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