COVER SHEET

INFOMECHATRONICS: Design and Development of First Undergraduate Inter-Disciplinary Engineering Course in Pacific Region

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ABSTRACT

This paper presents an educational view on the concept of Infomechatronics as a logical development of rationalisation and integration across the traditional disciplines of mechanical engineering, electrical and electronic engineering and information technology. As a synergy of core technologies, the combined application of computers and electronic instrumentation is becoming an important component of modern machinery and processes. In order to gain a competitive edge in the modern manufacturing era where the products and the processes are becoming highly integrated in functionalities, it is essential to have workforce with inter-disciplinary knowledge. The development of Infomechatronics will therefore be essential in order to maintain the continued competitiveness among various industries such as manufacturing, construction, maintenance, mining, food processing and other service industries. This paper also discusses the growing trend towards inter-faculty knowledge requirement of engineering graduates in current industry and the development of four-year undergraduate degree in Infomechatronics Engineering at Queensland University of Technology, Australia.

1. INTRODUCTION AND BACKGROUND

Researchers throughout the world realised in late 1960s that it is essential to introduce a term that reflect the increasing interaction between the mechanical and electronics engineering disciplines in the operations of many systems [1]. 'Mechatronics' was then first introduced and registered by an engineer called Tesuro Mori of Yasaka Electric company [2] to provide a semantic reference to this phenomenon. Mechatronics in its fundamental form can be regarded as the fusion of mechanical and electrical disciplines in modern engineering processes. It was relatively a new concept relating to the design of systems, devices and products aimed at achieving an optimal balance between basic mechanical structure and its overall control. The term Mechatronics was subsequently used to refer simplified mechanisms with sophisticated functions in electronics [3]. The interaction of technologies is still continuously evolving and dynamic state due to major advances in information technology, micro-processor-controlled systems and digital communications and their incorporation in modern machinery and processes. By considering these recent developments and to reflect current state of interaction of technologies the word Infomechatronics is introduced. The word Infomechatronics was evolved by amalgamating the three traditional engineering disciplines **INFO**rmation Technology, **MECHA**nical and Elec**TRONICS** and the formation is shown in Fig.1.

2. CURRENT STATUS

Mechanical engineering degree courses have always incorporated some element of electrical technology within the core syllabus material. In the early 1960s the emphasis in electrical technology for mechanical engineers was generally restricted to the generation, transmission and utilisation of electrical power with little emphasis on microelectronics and

computer science [4]. With later development and introduction of integrated circuits and microprocessors, some of these issues are introduced in mechanical engineering curriculum in early 1970s. The idea behind this introduction was to make a mechanical engineer to familiar with the operating characteristics, performance and practical applications of these devices rather than design of integrated circuits [5]. In the 1980s the expansion of microprocessor-based products has becomes tremendous and unimaginable. It is hardly surprising that the microcomputer has encroached into every aspect of mechanical engineering. Initially they are used for their data handling capabilities, there after the microcomputers are used in countless applications to systems monitoring and control and other related applications. At this stage mechanical engineers are can no longer afford to restrict their interest to the purely mechanical aspects of design. This does not mean that the mechanical aspects are still important. What is more important is the overall design concept in which greater emphasis is placed on what the sub systems can do, rather considering their independent details. These sub systems comprise the control functions, the power systems; issues related to data communications, networking and communication interfaces. As the benefits associated with applications of Mechatronics become evident, the education systems in many countries are taking note of importance and relevance of this technology era. By considering most of these issues many universities throughout world introduced the Mechatronics curriculum at undergraduate level in mid 1990s [6-10].

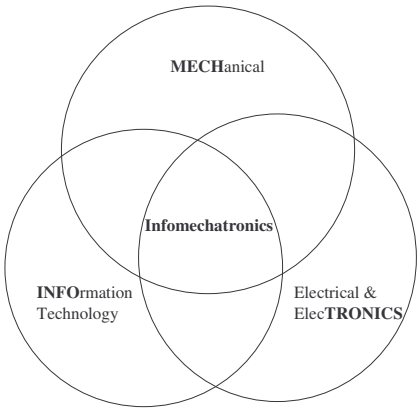

Fig.1 Definition of Infomechatronics

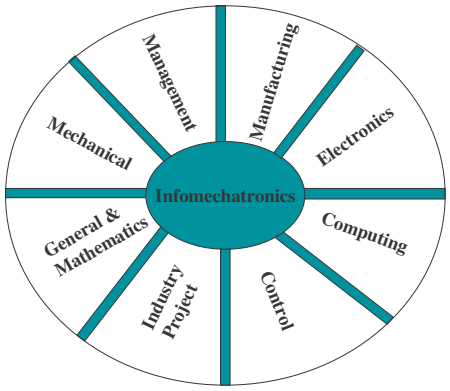

Fig. 2 Illustration of Major Streams in the Infomechatronics Course

3. INFOMECHATRONICS CURRICULUM DEVELOPMENT ISSUES

Engineering education is commonly based on single discipline activities and founded on a 'bottom-up' approach. The bottom-up approach builds on fundamental principles and concepts and is predominantly geared towards pure research. Even though the research is quite effective from innovation and creativity point of view, it is not so effective when it comes to the industrial exploitation of research. The success of any industry, especially manufacturing industry depends on anticipating market trends and being able to respond rapidly to offer new products to meet the changing demands. Engineers and technologists working in this kind of dynamic environment need to be aware and concerned about the end product and are required to develop a systems approach to design, where the overall objective take precedence over the individual components and sub-systems [4]. The systematic attitude in combining the principles of non-related technologies is the philosophy of Infomechatronics. Major streams in the Infomechatronics course are shown in Fig.2.

3.1 Necessity for a New Infomechatronics Course

Since late 1980s many universities have introduced courses in Mechatronics in recognition of the growing demand for engineers who have the skills to design, develop, build and service machinery/ devices that combine electrical phenomena and mechanical structures in new synergy. In the last decade microprocessors and information technology have profoundly changed the nature of machines creating the need for an engineer knowledgeable in the three areas of information technology, electrical and electronic engineering and mechanical design and fabrication. A detailed survey of potential employers was carried out, and the outcome of the survey indicated that engineers with the described multi-disciplinary skills would be in high demand. In the current situation, the demand is partially met by informal postgraduate self-education and on the-job training. Typically, electronic engineers pick up additional knowledge in information technology, and in some cases, information technology graduates deepen their knowledge of electronics. To overcome this inefficient situation, several universities have incorporated more information technology into their mechatronic courses. Currently, such comprehensive courses are scarce in Australia and non-existent in Queensland. There is an opportunity for QUT to move quickly and become a leader in this emerging market.

Modern devices and systems are characterised by the use of digital computers to provide increased functionality and autonomy at decreased cost. Mechanical and electronic sensors provide the information to the digital processors that steer complex operations through electro-mechanical actuators. Mechanical, electronic and computer components fuse into one functional entity in areas ranging from aeroplanes, cars, industrial robots and automata down to disk drives, copiers, printers, industrial and domestic appliances. None of the existing courses offered by Australian universities can be extended or adapted to meet the objectives described above. The BE (Infomechatronics) aims to provide the education and skills required for the design, development, construction and service of modern machinery, devices and systems by drawing on all three traditionally separate disciplines of mechanical engineering, electrical and electronic engineering, and computing. Such combined skills are becoming essential across all industrial sectors: manufacturing and process industries, primary production and mining, and the service and health industries.

3.2 Infomechatronics Course Objectives

- To produce an engineering graduate with broad knowledge and skills across the three engineering disciplines of Information Technology, Electrical & Electronic and Mechanical & Manufacturing Engineering who meet the needs of industry with respect to the design, fabrication and service of computer controlled industrial machinery and consumer products.
- To provide a broad-based academic training program aimed at producing future industry managers who can be effective in research and technology whilst leading industry in an innovative, efficient and socially responsible way.
- To provide, prior to entry to the work force, a course of study in engineering science and technology with adequate awareness of the importance of a multi-disciplinary approach to the optimal design and fabrication of computer controlled machinery.
- To develop good communication, leadership, managerial, and life long learning skills.
- To develop in graduates a high degree of competence and confidence within their chosen areas of study that will facilitate their ready acceptance into work force in commerce, industry & government.
- To develop in graduates a sound knowledge and understanding of the fundamentals of their discipline so that they can adapt to scientific, technological and social changes.
- To develop the capability for critical thinking and analysis to apply the knowledge gained from their course of study to the solution of real life problems
- To instill a sensitivity to and understanding of culture and gender related issues as they relate to professional and ethical practices.

3.3 Infomechatronics Course Structure

The BE (Infomechatronics) is of a multi-disciplinary nature. Traditionally, at Queensland University of Technology cross-disciplinary courses have been implemented as double degrees. However, such an approach was considered inappropriate by considering the current problems faced by most of the faculties offering double degrees and also the problems faced by the students during their course of study. Instead the decision was made in favour of a four-year engineering degree with a carefully chosen selection of units from three existing degrees. Thorough consideration was given to the mix and sequencing of the units, and many delicate compromises had to be made to achieve the dual, and often conflicting purposes, of providing a solid and coherent base of knowledge and maximising the use of existing units. The course consists of 4 units from the Faculty of Information Technology and 10 units from the Schools of Mechanical, Manufacturing and Medical Engineering and 6 units from the School of Electrical and Electronic Systems Engineering. The contributions of different schools for the proposed course are given in the Table-1. The structure of the proposed course has been designed with the clear intention of obtaining full accreditation from the Institution of Engineers, Australia by giving due consideration for the load distribution in different subject areas. To accommodate a more flexible entry approach to the courses, prior recognition may be given to the units and courses of QUT and/of other local and international recognised institutions.

Table 1. Load Distributions of Different Disciplines in Infomechatronics Course

Name of the School	**% of Load**	**No. of Units**
Mech., Mfg., & Medical Engineering	31.25	10
Faculty of Information Technology	12.50	4
Electrical &Electronics Engineering	18.75	6
Faculty of Business	3.125	1
Civil Engineering	3.125	1
Physics	3.125	1
Mathematics	12.50	4
Final Year Project	9.375	3
Electives	6.250	2

This undergraduate course is designed to provide professional engineers with multi-disciplinary skills and in-depth knowledge. In this course, emphasis is placed on providing inter-school/inter-faculty training to the students in addition to providing problem identification, formulation and solving, oral and written communication skills. Units are taught within the framework of the School's teaching and learning guidelines, which aim to produce graduates who will be leaders in their profession. The school's guidelines also emphasise flexibility in delivery, self-learning, creativity and critical thinking. The course provides a foundation in basic engineering sciences, mechanics, manufacturing technologies, electronics and electrical machines, sensors actuators, control, real time embedded and distributed computing. Projects and specialisation units emphasise the combination of mechanical, electronic and computing knowledge in the design, construction and maintenance of complex machinery/devices/systems. The proposed course was designed by using many existing units from the courses in mechanical engineering, electrical engineering and information technology. The units for this course was selected to meet the aims and objectives outlined in the previous section in this paper. Successful completion of the course involves undertaking 384 credit points across 8 semesters of full-time study. The course consists of 324 credit points of core material (27 units), 24 credit points of elective material (2 units) and 36 credit points of industry project in the final year. In accordance with the nature of the course and existing guidelines on elective units, students may

choose any QUT unit as elective units. An overview of the course structure and unit names is presented in Table-2.

Table 2. Overview of Infomechatronics Course Structure

Year	Semester 1 (48 cp)	Semester 2 (48 cp)
First Year	MAB131 Engineering Mathematics 1a CEB109 Engineering Mechanics PCB136 Engineering Physics 1C ITB510 Communications Networks	MAB132 Engineering Mathematics 1b MMB112 Dynamics EEB213 Electrical Circuits and Measurements BNB007 Professional Studies
Second Year	MAB134 Engineering Mathematics 3 MMB131 Engineering Materials EEB312 Electronics and Computing 1 ITB411 Software Development 2	MAB135 Engineering Mathematics 4 MMB252 Thermofluids MMB476 Operations Management EEB412 Electronics & Computing 2
Third Year	MMB211 Mechanics 1 MMB371 Manufacturing Processes EEB311 Control, Electrical Power and Machines 1 EEB521 Digital Systems and Control	MMB212 Mechanics 2 EEB411 Control, Electrical Power and Machines 2 MMB374 Design for Manufacturing 1 ITB465 Concurrent and Distributed Systems
Fourth Year	MMB004 Infomechatronics Project Elective I	MGB007 Engineering Management MMB478 Mechatronics System Design ITB847 Computational Intelligence for control and embedded systems Elective II

The Infomechatronics curriculum is developed is developed in terms of eight major streams or modules with close interaction between the different module groups. The major streams are: (i) General and Mathematics, (ii) Management, (Iii) Mechanical, (iv) Manufacturing, (v) Electronics, (vi) Sensors and Actuators, (vii) computing and (viii) Industry project. While engineering students acquire information and knowledge through formal lecture and laboratory programmes, it is important that they are afforded the opportunity to relate their learning experience to the reality of industry. This is best implemented through industrially-based projects where the students are faced with real engineering decisions and the responsibility for their own designs. In learning through doing, students have to organise their time effectively and efficiently to enable critical appraisal of a problem to be undertaken, a solution to be devised and a working prototype to be manufactured. Industrially-based projects additionally foster such personal qualities as creative ability, imagination, communication skills, and initiative and maturity [4]. In order to promote these qualities among graduates of this course a full semester industry project is introduced in the fourth year first semester.

3.4 Consideration of Teaching, Learning and Assessment in Infomechatronics Course

The teaching methods used in the course have been planned to meet the learning needs of the target groups of school leaving students and technologists. All the units within the course will be delivered in a combination format of lectures, tutorials, class room discussions/assigned reading materials, site visits, discussion groups, interaction between the instructor and the students and among students. Active learning or learning while doing is an underlying principle of this course. Emphasis will be placed on independent student learning and a range of teaching delivery methods to transfer skills and knowledge. The majority of assessment will be via assignments, seminars, group projects and examination (with a minimum weighting of 50%). The lecturers teaching various units (Student Evaluation of Teaching), the design and content of the individual units (Student Evaluation of Unit), and the program itself will be routinely evaluated by the students. Infomechatronic students may, optionally, participate in an

innovative learning project funded by CUTSD. In this project students participate in a multi-disciplinary student team dedicated to solving prototypical technology problems in a competitive setting that emulates R&D activity in technology intensive industries.

3.5 Course Monitoring and Improvement

The course advisory board and the course coordinator will monitor the course through interaction between staff and students, and will undertake a survey at the end of each semester to ensure that the objectives of the course are met and also to make sure that the emphasis of the course is appropriate to the needs and requirements of industry. In addition members of course advisory committee meet at the end of each semester to review various issues related to course quality and improvement. The course monitoring and quality assurance plan has been developed to look into various issues related to quality and delivery of course.

4. CONCLUSIONS

The developments of information technology and its applications in various engineering disciplines can be referred as the third industrial revolution. As the twenty-first century starting, it is essential that the mechanical engineers will require a broad range of knowledge in order to keep abreast of the latest technological developments. Engineering education has a fundamental impact on the future design and manufacturing of products and systems. The development of this Infomechatronics course and its thinking attitude leads to integration of diverse technologies rather than simply combined. This integrated educational experience will produce the necessary capabilities required to graduate engineer for modern manufacturing, maintenance and process industries. At present attempts are being made to develop the course structure for advanced standing program. The advanced standing program will be mainly used for mid term entry of students who completed an advanced diploma at a recognised overseas institution or to accommodate TAFE graduates from Australian institutions.

REFERENCES

1. Dinsdale J and Yamazaki K. Mechatronics and ASICs, Keynote Paper *Annals of the CIRP* 1989;38: 627-634 .
2. Kyura N, and Oho H. Mechatronics – an industrial perspective. *IEEE/ASME Transactions on Mechatronics* 1996;1(1):5-10.
3. Tan KK, Lee TH, Dou HF, and Lim SY. Various developments in Mechatronics in Asia. *Mechatronics* 1998;8:777-791.
4. Fraser CJ, Milne JS, and Logan GM. An educational perspective on applied Mechatronics. *Mechatronics* 1993;3(1):49-57.
5. Milne JS and Fraser CJ. Development of a Mechatronics learning facility. *Mechatronic Systems Engineering* 1990;1:31-40.
6. Venuvinod PK, Chen LW, Leung DNK and Rao KP. Development of the first mechatronic engineering degree course in the far east, *Mechatronics* 1993;3(5):537-541.
7. Janocha H. Mechatronics from the point of view of German universities. *Mechatronics* 1993;3(5):543-558.
8. Graham GR, and Morgan L. Problems-based learning in a mechatronic engineering degree. *Proc. of Waves of Change. Australian Association of Engineering Education*, Gladstone, Australia 1998;11-14.
9. Bradley DA, and Dawspm D. Achieving integration in engineering design education: The role of mechatronics. *Mechatronics Systems Engineering* 1990;1(1):19-29.
10. Craig K, and Marchi J.De. Mechatronic system design at Rensselaer. *Computer Applications in Engineering Education* 1996;4(1):67-78.