

Mechatronics Education in Singapore

Cheah Choo Lek
ccl@np.ac.sg

Chan Kwan Yew
ckyl@np.ac.sg

Department of Mechanical Engineering
Ngee Ann Polytechnic, Singapore

Abstract

Mechatronics is offered at Diploma level by all the four Polytechnics in Singapore, to meet the demand of the manufacturing and electronics-related industries for technologists capable of an interdisciplinary and integrated approach to problem-solving. This paper gives a general overview of the Diploma programmes, and briefly touches on the BEng (Mechanical & Production) with Specialisation in Mechatronics at Nanyang Technological University and the Master of Science in Mechatronics at the National University of Singapore, which provide a route for traditional single-discipline graduates to become multi-discipline Mechatronics engineers. The focus of the paper is on the course offered by Ngee Ann Polytechnic, its approach and philosophy as a case study to illustrate our views on Mechatronics education. The paper concludes by raising the issue of recognition of Mechatronics as a discipline by professional bodies.

1. Introduction

Mechatronics has been identified to be a relevant discipline to help Singapore achieve sustained competitiveness of its industries. The objective is to develop a strong technological capability in the design of high value-added products, and to support the semiconductor/wafer fabrication industries. In its ambitious "Industry 21" plan, the Economic Development Board (EDB) of Singapore aims to establish global leadership in manufacturing solutions, and in the creation and management of new products, applications and markets; and targets the growth of the electronic industry to be 8 per cent annually, to generate S\$150 billion worth of output by the year 2010 ^[1].

2. Mechatronics Education at Diploma Level

At present there are four polytechnics in Singapore, namely, Nanyang Polytechnic, Ngee Ann Polytechnic, Singapore Polytechnic and Temasek Polytechnic, all of which are Government funded. To meet the manpower needs for industries such as data storage and imaging, computer, communication, consumer electronics, and semiconductor, these institutions offer a total of 1240 places to "O"-level school leavers to pursue the three-year Diploma course in Mechatronics in 1999 ^[2].

While there may be slight differences in the approach and emphasis of these courses offered by the four Polytechnics, some with further specialisation, the basic curricula and the standards are largely similar as the courses all lead to the award of a Diploma fully recognised by the Government and local employers. In section 4,

the course at Ngee Ann Polytechnic, its approach and philosophy will be described as a case study to illustrate our views on Mechatronics education.

3. Mechatronics Education at Graduate/Postgraduate Level

3.1 *BEng (Mechanical & Production) with Specialisation in Mechatronics at Nanyang Technological University (NTU)*^[3]

In response to industry trends, a 'Mechatronics Specialisation Stream' has been initiated by NTU in the existing mainstream Mechanical and Production Engineering (MPE) undergraduate curriculum. The objectives of the specialisation programme are principally:

- to train MPE graduates to be competent in the field of Mechatronics in areas such as electronics, computing, control and mechanical systems, and
- to enable them to apply the relevant knowledge and technologies for the design and realisation of innovative systems and products.

With a strong foundation in the basic mechanical engineering in year one, a selected group of undergraduates at NTU can be further educated in the control, computing, and electronics aspects of Mechatronics in order for them to be competent in the creation of products, machines, and the various forms of robotics.

The specialisation programme builds upon the foundation of Mechanical Engineering. Students will be required to read basic subjects in the Year 1 Common Engineering and the mainstream Year 2 BEng (MPE) course with a number of adjustments and additions. As shown in the course structure in Figure 1, the Mechatronics Specialisation programme adopts a two-pronged approach to the teaching of Mechatronics comprising:

- the teaching of fundamentals and theories relevant to Mechatronics, and
- an integrated and progressive practical approach to mechatronics design and realisation using projects and case studies.



Figure 1

3.2 Master of Science in Mechatronics at National University of Singapore (NUS) ^[4,5]

The modules offered in the MSc (Mechatronics) Program by NUS are divided into 4 core modules, 7 foundation modules, and 21 technical electives. Each module in general consists of 39 hours of lecture and laboratory work and is spread over a 13-week period. Students meet one evening per week per module. The modules are offered in the evening to cater for working professionals.

The curriculum consists of four core (compulsory) modules which includes a 1-year Mechatronic System Design module. In this module, the candidate will undertake a design-and-build project involving a mechatronic product or system. Owing to the inter-disciplinary nature of the project, the candidate will have two project supervisors, one each from the Departments of Electrical and Mechanical Engineering. As almost all students come from technology-based industries where mechatronics is an enabling technology, they are encouraged to propose projects for the Mechatronic System Design module. In such cases, one of the project supervisors would come from industry. To facilitate project work and experimental work associated with the modules, three laboratories in the Departments will be opened for three evenings per week.

In addition to the four core modules, the candidate must successfully pass five optional modules, of which at least two must be *foundation* modules, and at least two must be *specialised* modules. The foundation modules are designed to cater for students of different backgrounds. For example, students with Electrical Engineering background are expected to take Mechanical Components and Systems. Students with Mechanical Engineering background are expected to take Electrical Components and Systems. The specialised modules are technical electives of a focused nature such as Intelligent Systems, Factory Automation, etc. with a module on Special Topics in Mechatronics to cater for emerging technologies and new topics. Detailed syllabi of all the modules can be found in <http://www.eng.nus.sg/mpe/MCH>.

4. Mechatronics Curriculum at Ngee Ann Polytechnic ^[6]

4.1 Background

The Diploma programme in Mechatronic Engineering was set up jointly between the Department of Mechanical Engineering and Department of Electronic and Computer Engineering in response to a need in industry for technologists capable of an interdisciplinary and integrated approach to engineering problem-solving encountered in multi-disciplinary processes and products that are increasingly found in modern manufacturing eg. in the various sectors of the electronic manufacturing industry. The Diploma in Mechatronic Engineering was first conducted as a Full Time Equivalent (FTE) course in 1989.

The full-time Diploma in Mechatronic Engineering course saw the first intake of 90 students in 1991. This batch graduated in 1994. The total enrolment for the three levels was 487 as at January 1999.

The original course curriculum was planned to produce graduates whose skills and knowledge are not confined to a single discipline but who are capable and confident of operating and communicating across a range of engineering disciplines and by doing so, provide a link between those with more specialised skills.

The course underwent a major revision which was implemented year by year commencing with Level 1 in July 1996. This was in response to the findings of an external consultant and supported by feedback from staff and students. The course curriculum is appended as Appendix 1. Details of the course structure and curriculum can be found at <http://www.np.edu.sg/~dept-me/dip-mte.htm>.

4.2 Course Philosophy

The philosophy and therefore the structure of the mechatronics course in Ngee Ann Polytechnic is encompassed in our "typical" mechatronic model shown in Figure 2.

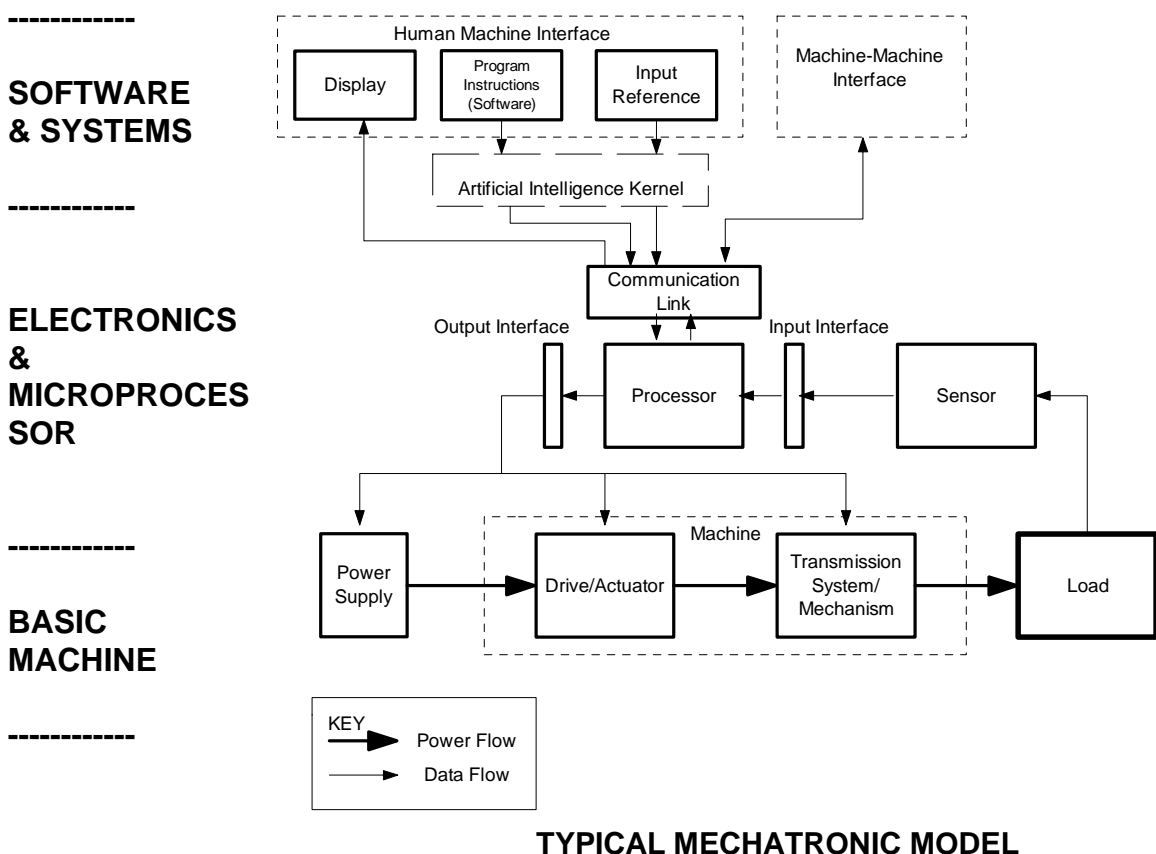


Figure 2

In our model, an understanding of the operating principles of machines is the basic foundation. Electronics, especially in the form of sensors and microprocessors and their interfaces are then incorporated to impart intelligence to the machine and to

"close the loop" for control of the machine. Software is used to provide versatility, accuracy and intelligence in the control. Communication and data exchange between man and machine as well as machine to machine enable individual machines to work together in an intelligent factory and global environment.

4.3 Main Thrusts of the Programme

The revised curriculum for the 3-year Diploma programme in Mechatronic Engineering is designed along this approach as an integrated system of training, combining the fundamentals of mechanical and electronic engineering as well as information technology to meet the needs of industries involved in automation, robotics and related areas, where there is a need to integrate these technologies.

The first level of the course provides broad-based studies in basic mechanical and electronic engineering principles, engineering mathematics and computing. These will be taught with constant reference to the abovementioned "philosophy" of mechatronics

In the second level of study, students will make use of the basic building blocks they acquired in the first level to build up the basic mechatronic model described above ie. drives, transmission, sensor, processor as well as principles of modelling and control of the system, interfacing and implementation of software for engineering applications. At the end of this level, students will undergo eight weeks of attachment to industry to apply their knowledge and to gain valuable industrial experience.

The third level focuses on integrated systems like manufacturing automation systems and systems integration, mechatronic system design, robotics, machine vision digital control and intelligent systems.

The final-year project represents the culmination of the mechatronic training as students apply the wide range of skills and knowledge acquired during the course. The design-and-build project reinforces the integrated approach to modern-day engineering practices. Students will have opportunities to work in teams as well as to practise their productivity and quality concepts and in oral and written communication skills, which are taught in this final level, during group interaction, discussions and the presentation of their results.

The general objective of this course is to provide a broad foundation in the field, one upon which students can build and to which concepts from other related fields can be applied. The emphasis lies on projecting a conceptual framework that will serve the practitioner well as the field continues to evolve. After completing the course, students will also have some background in production and supervisory management, productivity tools and communication skills.

While catering to the needs of industry, our Diploma course has good academic standing. Many of our graduates have been admitted to and have graduated from both overseas as well as the National University of Singapore and the Nanyang Technological University in Singapore. Most of them have been granted full or

partial exemption from the first year of studies, to read Mechatronic, Mechanical, Electronic Engineering or related areas eg. Information Technology.

5. Conclusion

There is no doubt that industry in Singapore recognises the opportunities and benefits to be gained from the integrated use of electronics, mechanical and computer technologies in products and systems design. The corresponding need to train engineers and technologists capable of applying multi-disciplinary technology in problem-solving is, to a large extent, met by the current Mechatronics courses offered by the four Polytechnics and two Universities described in this paper. As more smart components and systems come on stream, the demand for Mechatronics education should grow.

However, the professional and regulatory bodies for engineers in Singapore appear to have been slow in recognising Mechatronic Engineering as a discipline. This possibly has contributed to the perception by the two local Universities that time is not yet ripe for Mechatronic Engineering to be offered at Bachelor's degree level. Instead they choose to enhance their undergraduate curricula through a Mechatronics Specialisation programme or to offer a Master's programme to provide a route for traditional single-discipline graduates to become multi-discipline Mechatronics engineers. This indirectly has created an identity crisis among some students in the Mechatronics course, who may perceive themselves as future "half-baked" mechanical or electronic engineers or technologists. This can compound the problem of dwindling interest among youngsters in taking up engineering as their course of choice. In the Singapore context, this raises an issue that we educators in Mechatronics must address.

References

1. Economic Development Board (EDB) Singapore, *Industry 21*, @ <http://www.sedb.sg>
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3. Nanyang Technological University, *Proposed Specialisation Programme*, Internal Document
4. Marcelo H. Ang Jr., *The Master of Science Program at the National University of Singapore*, Trans-Pacific Workshop on Mechatronic Technology 1997 (TPMT' 97), Feb 25-28, Japan
5. Marcelo H. Ang Jr., *Mechatronics Education for Mechanical Engineering Students at the National University of Singapore*, Trans-Pacific Workshop on Mechatronic Technology 1997 (TPMT' 97), Feb 25-28, Japan
6. Ngee Ann Polytechnic, *Diploma in Mechatronic Engineering*, Course Document

Appendix A: Curriculum for Diploma in Mechatronic Engineering

Level 1

LEVEL 1.1 MODULES	HRS/WK	LEVEL 1.2 MODULES	HRS/WK
Engineering Mathematics 1	6	Engineering Mathematics 2	6
Creativity & Innovation	3*	Computer Programming	4*
Fundamentals of Electrical Engineering	6	Electronic Devices and Circuits	6
Modern Engineering Materials	3	Fundamentals of Mechanical Engineering	8
Manufacturing Technology & Practice	8*	Engineering Drawing & CAD	4*
Physical Education	2*		
	28		28

Level 2

LEVEL 2.1 MODULES	HRS/WK	LEVEL 2.2 MODULES	HRS/WK
Systems Modelling & Control	6	Engineering Mathematics 3	6
Digital Electronics	6	Microprocessor Programming	6
Sensor Technology	4	Industrial Automation	4
Electric & Hydraulic Drives	8	Mechanical Aspects of Mechatronic Systems	6
Mechatronics Engineering Practice	4*	Programming For Engineering Applications	4*
Vacation Training Programme		Electronic CAD	2*
	28		28

Level 3

LEVEL 3.1. MODULES	HRS/WK	LEVEL 3.2 MODULES	HRS/WK
Mechatronic Project 1	6*	Mechatronic Project 2	6*
Communications Skills 1	2*	Communications Skills 2	2*
Microprocessor Interfacing & Applications	6	Robotics and Machine Vision	5
Manufacturing Automation Systems	6	Manufacturing Systems Integration	5
Digital Control & Intelligent Systems	5	Mechatronic Systems Design	5*
Productivity, Quality Studies	2*	Management Studies	4
Social & Community Values 1	1*	Social & Community Values 2	1*
	28		28

* denotes a continuous-assessment module.