J26

Mechatronics Vol. 3, No. 5, pp. 537–541, 1993
Printed in Great Britain

0957-4158/93 $6.00+0.00

DEVELOPMENT OF THE FIRST MECHATRONIC ENGINEERING DEGREE COURSE IN THE FAR EAST

P. K. VENUVINOD,* LAWRENCE W. CHAN,† DENNIS N. K. LEUNG‡ and K. P. RAO*

City Polytechnic of Hong Kong, Kowloon, Hong Kong

(*Received* 2 *January* 1993; *accepted* 23 *January* 1993)

Abstract—This paper discusses the growing trend towards mechatronics in Hong Kong and the development of the honours degree course in Mechatronic Engineering at the City Polytechnic of Hong Kong.

INTRODUCTION

In the last 30 years, Hong Kong has developed into one of the world's major manufacturing centres. In the initial stages, the local accent was mostly on productivity improvement. In the last few years, Hong Kong has moved towards higher quality products. The eighties have seen a general awareness that unless Hong Kong modernizes its industries, moves upmarket to higher value-added products and so on, Hong Kong will not be able to withstand global competition (especially from the other dragons and the developing countries). The need for such a transition is further underlined by the rapid erosion of Hong Kong's advantage in terms of lower wages, the transfer of low-end manufacturing operations across the border to China, and the rise of the service sector in relation to the manufacturing sector.

During the last decade, the manufacturing industry in Hong Kong has seen significant modernization through two parallel developments. Firstly, many computer-based manufacturing technologies have been adopted by several local industries. As a result, the processing machinery in many local industries is becoming more and more mechatronic. Secondly, Hong Kong industries seem to be moving beyond the long tradition of manufacturing OEM products.

With a substantial growth in the electronic products manufacturing sector in Hong Kong, many industries have embarked on in-house design activities. Thus, while Hong Kong continues to produce for overseas brand names, much of the upstream product development activity is being progressively transferred to Hong Kong. This is being facilitated by a parallel growth in other design infrastructure in terms of design houses, mould design, mould making, etc. Even in industries dominated by OEM products, much re-design work goes into fine tuning the design in order to meet the

*Department of Manufacturing Engineering.
†Industrial Liaison Officer.
‡Department of Electronic Engineering.

requirements of the local manufacturing facilities. Since design is the most value-added component of the design–make cycle, it can be anticipated that the trend towards increasing local design content will be accelerated in the future. Further, due to the relative and growing strength of our electronic products sector (which almost exclusively produces consumer, not engineering products), there seems to be a growing need for consumer mechatronic products designers.

NATURE OF MECHATRONICS, PRODUCTS AND SYSTEMS

The subject field of machine systems, ranging from consumer products to complex machinery is experiencing a far-reaching revolution concerning their technological make-up. Thus, mechanical engineering has combined with electronics and computer control in a closely-integrated way to conceive and develop products and processes which would not have been possible without such a multi-disciplinary approach. The recently-coined term for this approach to engineering design is "Mechatronics" [1, 2].

Several definitions for 'Mechatronics' are available in the literature.

(i) "The application of microelectronics in mechanical engineering": the original definition by MITI, of Japan.
(ii) "A combination of mechanical engineering, electronic control and systems engineering in the design of products and processes."
(iii) "A synergistic combination of precision mechanical engineering, electronic control and systems thinking in the design of products and manufacturing processes": according to IRDAC, the Industrial Research and Development Advisory Committee, of the European Community (EC).

With a mechatronic design, products can be realized which, in each of the disciplines alone, may be difficult or even impossible to realize. The result is a product with superior design specifications and, hence, with greater value added.

Many of the significant improvements in mechatronic systems have been due to the continuous development of information processes, e.g. more user-friendly interfaces. Yet, it is control engineering (in particular, motion control), which is the key to success of mechatronic systems. One of the most important features of the mechatronic system is the flexible combination of a simple mechanism with a sophisticated control system. Clearly, neither the mechanical nor the electronic engineer is capable of migrating from the classical to the modern on his own. Such a migration requires the interdisciplinary expertise we call 'mechatronics'.

In addition to mechanical, electronic and software engineering, mechatronic design engineering involves the consideration of aspects related to industrial design, manufacturing engineering and marketing.

From the industrial viewpoint, a mechatronic engineer should be particularly useful in:

(a) product mechatronics: i.e. in the design of mechatronic products; and
(b) process mechatronics: i.e. in the utilization, operation and maintenance of mechatronic process machinery—mainly in the manufacturing industry.

Product mechatronics could be further sub-divided into:

(a) consumer products—which tend to be mass produced, have shorter life cycles, and have greater pressures on cost, and greater requirements in terms of aesthetics; and
(b) engineering products—which tend to be technically much more complex.

The educational developments so far in the West and Japan have concentrated on the needs of mechatronic engineers involved in engineering products and process mechatronics (in that order). However, from a pedagogic viewpoint, the knowledge elements required for both these sectors overlap substantially. Further, the design of consumer products involves many other aspects. Thus, the needs of consumer product mechatronics have not yet been significantly addressed in the West and Japan.

However, from the viewpoint of Hong Kong, the primary need for mechatronics is in the context of consumer products and manufacturing processes. Mechatronic engineering in Hong Kong thus has to grapple with an underexplored dimension of mechatronics, i.e. consumer product mechatronics.

MECHATRONICS CURRICULUM AT THE CITY POLYTECHNIC OF HONG KONG

Having noted the nature of mechatronics engineering, the expected role of the graduates and the characteristics and abilities of the entrants to the course, the following principles have guided the curriculum design for the BEng(Honours) in mechatronic engineering being launched through collaboration between the departments of manufacturing engineering and electronic engineering at the City Polytechnic.

(i) Direct the course mainly towards meeting the needs of consumer mechatronic product design and process mechatronics related to the manufacturing industry.
(ii) Recognize that design:
- is a complex and open ended activity requiring the refinement of creativity and experience through application;
- is often a group activity in industrial practice;
- is a combination of art and science;
- requires a broad overview of market needs, business goals; and
- and currently available manufacturing technology.

(iii) While the Japanese view of the mechatronic engineer as a mechanical engineer whose education is broadened to include microprocessors, electronics, actuators and control is broadly valid, avoid, as far as possible, biasing the students towards a specific discipline—i.e. emphasize the inter-disciplinary approach.
(iv) Develop the mechanical and electronic design aspects systematically while providing a broad understanding of computers to enable their effective utilization in design.
(v) Recognize that control engineering (especially motion control) is a core activity.
(vi) Develop a broad understanding of the interactions between design, manufacturing and design management.

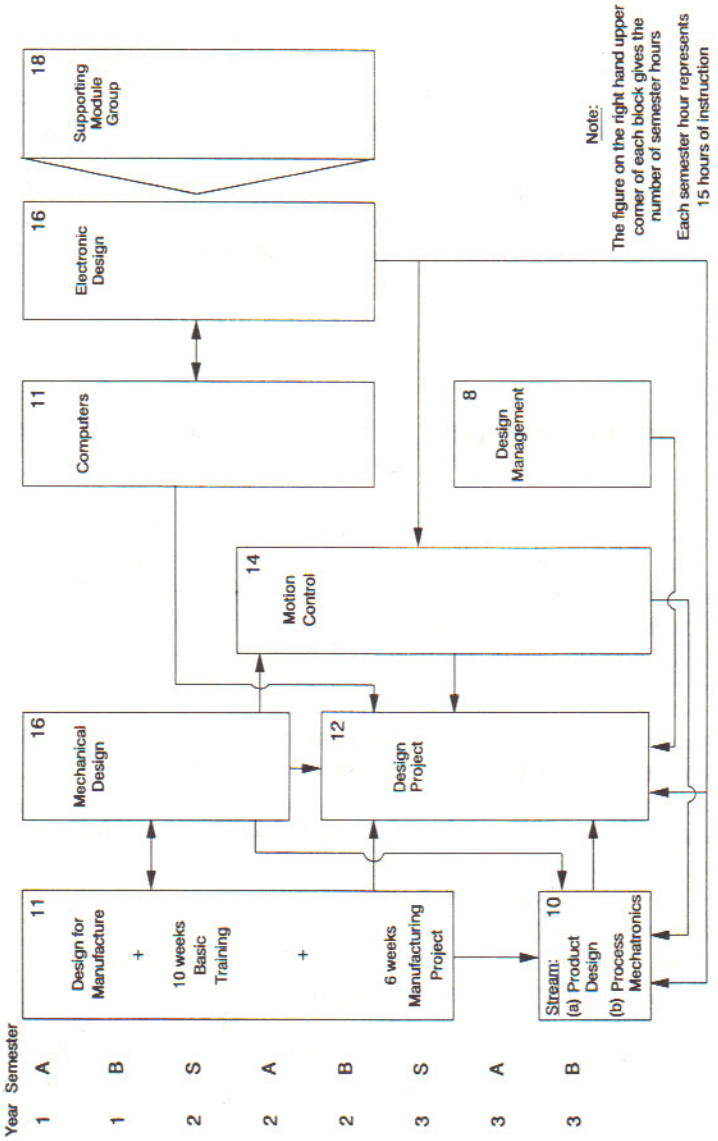

Fig. 1. Interactions between the module groups.

(vii) Take advantage of computer aided design and analysis (CAE) software in order to enable the students to undertake more substantial design tasks.
(viii) Develop the skills in technical communication which are required by all engineers.

The curriculum for the course is developed in terms of nine subjects groups or themes with close interaction between the different module groups, as shown in Fig. 1, which indicates the sequencing of the various module groups in a three year full-time program. The subject groups are: (i) Mechanical Design, (ii) Electronic Design, (iii) Computers, (iv) Design for Manufacture, (v) Motion Control, (vi) Design Management, (vii) Specialization, (viii) Supporting Modules, and (ix) Design Project.

In keeping with the special requirements of the study of design, the course has a significant proportion of time devoted to 'active learning' through 'doing' as opposed to 'passive learning' through attending lectures. Thus some 60% of the total contact time in the course is devoted to laboratory, project, tutorial and training components where the student is largely in the active learning mode. Practice in the design process itself extends over the entire course and much of this activity is done in groups—thus simulating the team environment in which design projects are typically executed in industry.

SUMMARY

After a thorough evaluation of the needs of Hong Kong industry, a mechatronic degree curriculum has been developed and the course has been launched. In this course, the main emphasis is placed on the design of consumer mechatronic products and process mechatronics, with control as the core activity, as opposed to other classical courses elsewhere which emphasizes robotics.

REFERENCES

1. Dinsdale J. and Yamazaki K., Mechatronics and ASICs, Keynote Paper. *Annals of the CIRP*, **38**, 627–634 (1989).
2. Dinsdale J., Mechatronics: the international scene. *Mechatron. Sys. Eng.* **1**, 101–105 (1990).