Development of an Innovative Undergraduate Industrial Automation and Robotics Degree Program

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Abstract

In recent years, the need for integrated engineering courses has increased. Due to its multidisciplinary nature, Industrial Automation and Robotics degree course is an ideal example of curriculum integration. This paper discusses several issues such as course offerings, topical content, student profile, student performance and other pertinent matters related to the recent development of an Industrial Automation and Robotics undergraduate degree programme at the University of Kuala Lumpur, Malaysia.

Keywords: Industrial Automation, Robotics, Curriculum Development, Undergraduate

1. Introduction

Industrial Automation and Robotics is a multidisciplinary science that encompasses the areas of computer science, mathematics, physics, mechanical engineering, industrial engineering, electrical engineering, computer engineering, materials science, and manufacturing engineering among others. It provides an opportunity to break the barriers between all these disciplines in a single course and it offers an excellent example of multidisciplinary integration for engineering students. In recent years, several institutions, following the lead of the robot-building course at the Massachusetts Institute of Technology [1], now offer robot building classes and laboratories. Some graduate level courses in Artificial Intelligence also rely on robot building techniques to illustrate general concepts of decision-making and machine intelligence [2], [3].

In Malaysia colleges, public and private universities offer many programs which lead to the degree of Bachelor of Engineering and Bachelor of Engineering Technology. These programmes range in topics from Electrical, Mechanical, Chemical, etc. With increasing frequency, employers are requiring employees in their engineering or technical staff to have multi-skills. Naturally, aspiring employees want to take-up inter-disciplinary courses to enhance their marketability. To help meet these desires, a new degree was developed by University Kuala Lumpur with the first batch of students enrolled in July 2002.

2. Planning Process

A number of authors have considered the broad issues associated with current and future trends in multidisciplinary engineering education [4], [5]. It is clear that there is no one correct curricula or approach to treating multidisciplinary engineering education. Rather, one must take into careful consideration the regional employment demands, as well as the preparation necessary for graduate study. It is necessary to practice careful discernment regarding the rapid technological fluctuations that are prevalent today. Specifically, industry can be expected to make regular demands of undergraduate preparation to meet their perceived needs [6], [7], [8]. Sometimes these expectations will provide valuable insights into changing career paths, and at other times the demands will be inappropriate, and best understood as related to the “tools and toys” of the trade. Engineering students must have a fundamental concept base which allows agility and flexibility, for if a program is too specialised, the range of opportunities available for graduates will be compromised. In the course of investigating the content and structure of a new program to address the design and development of the ‘industrial automation and robotics’ programme, it became clear that close ties to the fundamental disciplines associated with electrical engineering was critical. The wide variety of distributed sensors, their associated electronic interfaces, the large-scale control systems, and the extreme environments within which they operate require careful treatment of analog and digital electronic circuit design, communication and control theory, mathematics, and physics. These topics traditionally constitute the core of the electrical engineering discipline [9], [10].

A curriculum planning process is necessary to investigate the individual program topics, their relationships, and the pedagogy necessary to present them in an integrated fashion at an undergraduate level. We utilised two methods of inquiry to meet these goals. The first method of inquiry was based on a series of

formal meetings (both group and individual) with representatives drawn from our industrial partners and industrial advisory board. This varied group of people has been asked to consider their educational needs (industrial automation and robotics) based on the large and clearly identified trends in their industries. The second method involved the exploration of the substantial educational literature available including such publications as the IEEE Transactions on Education and the Journal of Engineering Education. At the end of the planning period, the following outcomes were generated:

- a compilation of the topical content for courses, particularly for topics that are new in the sense that they address emerging technologies and hence are non-traditional;
- a prioritisation of the topics since covering everything may not be feasible;
- a list of courses and their appropriate hierarchy in the curriculum;
- an identification of the necessary technologies that would be needed to offer this new curriculum so that appropriate acquisition of laboratory equipment could be addressed and the attendant facilities set up; and
- a time-bound roadmap for introducing the new curriculum

3. The Development of Bachelor of Engineering Technology Programme

The development of Bachelor of Engineering Technology Programme in Industrial Automation and Robotics Technology (IART) will discussed in the following paras. Once admitted into IART degree programme, the student takes a minimum of 120 semester credit hours of coursework (over 8 semesters) divided among four general categories of classes. The four areas are general studies, management, technical and industri training (INTRA) as shown in Table 1, where CH is the credit hours and TCH is the total credit hours.

Table 1: Subject Distribution of IART

NO	CATEOGORY	SUBJECTS	CH	%	TCH	%
1	General	LAN	9	7.31	25	20.32
		English	6	4.88		
		French	2	1.63		
		Mathematics	8	6.50		
2	Management	Unikl	4	3.25	15	12.19
		Mfi	11	8.94		
3	Technical	Automation	32	26.02	77	62.61
		Electrical	32	26.02		
		Mechanical	13	10.57		
4	Intra	Intra	6	4.88	06	4.88
	TOTAL CREDITS HOURS		**123**		**123**	**100%**

From Table 1, it can also be seen that the general studies is composed of 20.32%, management 12.19%, technical 62.61% and INTRA 4.88%. The total credits hours is 123. It is important to note that the department responsible for the technical concentration areas have specified the courses for each IART core area. Since concentration areas are attached to individual academic departments such department of automation, electrical and mechanical, this allows the individual departments a great deal of flexibility. There are currently 3 different technical concentrations available for the IART student, i.e., automation, electrical and mechanical.

Various subjects are offered in the 8 semesters. As an example, some of the subjects offered in semester 1 is shown in Table 2.

Table 2: Subjects of 1st Semester

No	Code	Subjects	Credit Hours	No. of Hrs Per Week	LEC	TD	P	No of Hrs Per Sem
1	AUT 3412	Introduction to Automation	2	3	1		2	54
2	FDE 3012	Engg. Drawing	2	3	2			54
3	ELE 3112	Electrical Fundamental	2	3	1		2	54
4	INM 3012	Safety Management	2	2	2			36
5	LAN 1002	Bahasa Malaysia	3	3	3			54
6	LAN 1004	Islamic (or Moral) Studies	3	3	3			54
7	MAT 3112	Mathematics 1	2	3	1	1.5		45
8	MAA 3012	Static and Dynamics	2	2.5	1	1.5		45
			18	22	14	3	4	396

From Table 2, it can seen that the subjects offered in semester 1 are 'Introduction to Automation', Engineering Drawing, Electrical Fundamental, Safety Management, Bahasa Malaysia, Islamic (Moral) Studies', 'Mathematics I' and 'Statics and Dynamics'. As an example, looking at 'Introduction to Automation', it can noted that it is 2 credits hours subject where the number of contact hours between the lecturers and students are 3 hours which is divided as 1 hour for lecture and 2 hours for practical. In one semester, 54 hours is allocated for this subject. A total of 396 'contact hours' takes place between the lecturers and students.

To look at the topical contents of the subjects offered, an example of a typical higher level subject is discussed below. The title of the subject title is known as 'Robotics I'. It is offered as a 3 credit hour core subject. Its main objective is to provide senior undergraduate students with broad knowledge on robots. The class consists of two and a half hours of lecture and tutorial, and a three-hour laboratory session weekly. The lecture and tutorial portion is used to teach fundamentals of robotics while the laboratory portion teaches 'hands on' robot programming techniques. The course is concerned with "classical" Robotics, which covers geometric models of robot manipulators, kinematics, dynamics, control, and path planning. Many excellent textbooks in this area are available. The authors have used and particularly recommends the texts by John J. Craig [6] or P. J. McKerrow [7].

The course contents are listed below:

- Review of Mathematical concepts. This part is a review and an introduction to trigonometric functions, vectors and matrices, and geometric transforms such as translations and rotations of objects in space. The use of Matlab in solving numerical problems is examined through lecture examples and homework assignments.
- Kinematics of robot manipulators. The use of the Denavit-Hartenberg model for robot manipulators is introduced and the study of direct and inverse kinematics is presented.
- Robot path planning and generation. Student are taught to use cubic splines to determine a path for the robot between two end points.
- Dynamics and Control of a Two-link robot. The students are introduced to the concepts of Newton-Euler dynamics only in the case of a two-link robot. Classical joint-position and velocity control is also examined without delving too deeply into this subject.
- Robot Manipulator Programming. A six-axis industrial robot, ABB and Staubli provides students with a test bed for robot manipulator programming. As a laboratory exercise, students program the ABB and Staubli, for a pick and place task or a simple assembly task.

4. Student Data

This section is divided into three sections, i.e., student profile in first section which encompasses the student intake and graduation, whilst the second section covers the student performance and the third section discusses about student employment.

4.1 Student Profile

The student profile which encompasses the student intake and graduation is given in Table 3.

Table 3: Student Profile

Intake	M	F	TOTAL
Batch July 2002	40	18	58
Batch July 2003	19	4	23

Final Semester	M	F	TOTAL
Batch July 2002	31	13	44
Batch July 2003	12	3	15

Graduate	M	F	TOTAL
Batch July 2002	30	11	41
Batch July 2003	12	3	15

Fail to Graduate	M	F	TOTAL
Batch July 2002	1	2	3
Batch July 2003	0	0	0

It can be seen from the Table 3, for the batch July 2002 out of 44 students, 41 manage to get the graduation and 3 fail to graduate. For the batch July 2003 all 15 students graduated.

The age group of batch July 2002 and batch July 2003 is shown in Table 4.

Table 4: Age Group

Age	28	27	26	25	24	23	22	21	Total
Batch July 2002	1	2	3	1	6	8	11	26	58
Batch July 2003		1				4	6	12	23

From Table 4, it can be seen that the age of the students enrolled in first semester varies from 21 to 28 years. The first and second batches had initial enrolment of 58 and 23 students. The higher age group is an evidence of candidates enrolement with some Industrial experience.

4.2 Student Performance

The final semester results for the batch July 2002 and July 2003 is shown in Table 5.

Table 5: Final Semester Results

Category	DL	KB	Total
Batch July 2002	3	38	41
Batch July 2003	4	11	15

DL	>3.5
KB	2.00-3.49
KP1	<2.00 1st time
KP2	<2.00 2nd time
GB	<1.00 or <2.00 3rd time
INC	Incomplete semester

From Table 5, it can be seen that in batch July 2002, 3 students fall under the category of DL and 38 students comes under the category of KB. Total number of students passed is 41.

In batch July 2003, 4 students fall under the category of DL and 11 students come under KB. Total number of students passed is 15.

The final CGPA results for the batch July 2002 and batch July 2003 is shown in the Table 6.

Table 6: Final Semester Results

CGPA	**<2.00**	**2.00-2.50**	**2.50-3.00**	**3.0-3.50**	**>3.5**	**Total**
Batch July 2002		3	26	9	3	41
Batch July 2003			10	5		15

From Table 6, it can be seen that in batch July 2002, 3 students have got final CGPA ranging from 2.00 to 2.50, 26 students have got CGPA ranging from 2.50 to 3.00, 9 students have got CGPA ranging from 3.00 to 3.50 and finally 3 students rated above 3.5 CGPA. Total passed is 41.

In batch July 2003, 10 students have got CGPA ranging from 2.50 to 3.00 and 5 students have got CGPA ranging from 3.00 to 3.50.Total passed is 15.

The trend of GPA for the batch July 2003 is shown in the Table 7.

Table 7: Trend of GPA

	KB	KP1	GB	INC	Total
Sem 2003/2	17		2	3	22
Sem 2004/1	13	3			16
Sem 2004/2	15				15
Sem 2005/1	15				15
Sem 2005/2	15				15
Sem 2006/1	15				15

The trend of GPA is shown in Table 7, it can be seen that for the batch July 2003 [Sem 2003/2] out of total 22 students, 17 got KB, 2 got GB and 3 doesn't complete the semester. In Sem 2004/1, 13 students come under KB and 3 come under KP1. In Sem 2004/2, 15 come under KB.In Sem 2005/1, 15 come under KB.In Sem 2005/2, 15 come under KB. In Sem 2006/1, 15 come under KB.

4.3 Student Employment

The majority of the students enrolled in the IART degree program are currently employed. In the first batch, 60-70% of students were able to find employment within 6 months of their graduation whereas 50-60% of the students were employed from the second batch which graduated in July 2006. They are employed in multinationals and as well as locally owned small and medium enterprises. Amongst the companies that there are attached with are Texas Instruments, Solectron, GlaxoSmith Kline, B Braun, Hicom, to name a few. At the time of writing this paper, it is already four months since the graduation of the second batch. As mentioned above, although 60% of them have found employment

within this period, it is expected that over time, the majority of graduates will find employment.

5.0 Conclusion

This paper has discussed the development of an multidisciplinary course in industrial automation and robotics for undergraduate engineering students. The IART degree offers a student with a completed diploma the opportunity to complete a bachelor's degree in a timely fashion, with little lose in transfer credits. The average CGPA of IART students are competitive, and employers recognise the degree and employ the graduates because of the academic content and the graduates' ability to perform, both academically and professionally.

Acknowledgements

The authors are grateful to Universiti Kuala Lumpur-Malaysia France Institute (UniKL-MFI) and UCSI University for the support. The authors would also like to extend their thanks to all the lecturers involved in Industrial Automation and Robotics Technology programme and Mechatronics Engineering Programme without whom this work might not be possible.

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