

**The process of updating Engineering Management Science in an Australian  
Regional University excellence in developing e-learning**

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## ***Abstract***

The aim of this paper is to share the processes in revising the courseware of the course of *Engineering Management Science* coded as ENG4004, in the Bachelor of Engineering (Mechanical, Mechatronics, Electrical and Electronic, Computer Systems, Instrumentation and Control), Bachelor of Engineering Technology (Mechanical, Building and Construction Management) programs offered by the University of Southern Queensland (USQ), a regional Australian University with excellence in developing e-learning (Good University Guides 2001; Morgan 1997). The paper describes how the authors review the courseware of the course. The needs for the review are also explained. The assessments of the course were also studied and revised. The authors also estimated the costs involved in reviewing the course. At the same time, the paper also predicts the benefits that will be offered to students and the community including employers who are going to employ USQ graduates. It is finally concluded that the review is worthwhile and the actual costs to the university are minimal.

***Keywords:*** engineering management science, operations research, critical path networks, linear programming, simulation, quality control, micro-economic functions, engineering degrees and mechanical engineering.

## ***Introduction***

In USQ, 'Engineering Management Science' is offered as the core course to seven engineering degree programs, ranging from building and construction management to

mechatronic engineering. It is a one-semester course and is only offered in semester two (2) every year and semester three (3) in alternate years. In addition, the course is also offered as face-to-face on-campus study as well as print based delivery, in which studybooks and other materials, e.g. CD-ROM are mailed to students worldwide. Additional supports given to off-campus students include communication by telephone, e-mails and WebCT (web computer technology) through the Internet (USQ Handbook, 2006). For the on-campus study, the course is currently available only at Toowoomba campus (Other campuses are in Fraser Coast and Springfield).

### *Need for review*

It is necessary to make a review on the topics and contents of the course because it had been offered in its present form for nine years. It is the time to see if some of the topics are to be changed, deleted or enriched. One enrichment necessary to the topics of the course is addition of the use of software packages, e.g. Microsoft Office Project Standard 2003. If these were absent, people will think that the course is out of date as most operations management textbooks included them in their topics. The methodology and tools used for the review include studying the contents of similar courses offered by other faculties of this university and by engineering faculties of other universities. Several international textbooks have been acquired and read by the authors; many of them are interesting and challenging. One most worth mentioning book is *Operations Management: Quality and Competitiveness in a Global Environment*, which was published by Wiley International in 2006. This book has a lot of Excel exhibits and worksheets which enable students to use for their study and practice at no extra cost. It will be prescribed as a textbook for S2, 2008 offer.

### *Study books*

In USQ, nearly all courses are delivered both on-campus and off-campus; USQ calls them hybrid mode; some courses are even delivered online. The study book for this course have been written for both on-campus and off-campus students. The cost of the this study book together with a book containing the solutions of self-assessment questions in the study book, plus an 'Introductory Book' containing two assignments and three sets of past examination papers for the course were included, is only 20 Australian dollars; the off-campus students will receive them free from the USQ Distance and e-Learning Centre via couriers. The current study book contains detailed information of each topic. It appears to the authors that students have substantial material to do well in the course. In addition, there are a lot of solved problems with detailed explanation on how they were solved. Students can easily learn the skills by attempting the self-assessment questions and past examination papers.

In USQ, a course team approach is used for the design and development of learning materials. The team consists of the course team leader, an instructional designer, and a materials development officer. Other specialist staffs in areas of multimedia, media, and graphics, publishing and copyright are utilized as required. Figure 1 shows the processes of design, development and production of a course in USQ (Fulcher, 2004).

### *Existing courseware in USQ*

The present courseware of *Engineering Management Science*, ENG4004 consist of five topics and can be found in Table 1. The contents of all USQ engineering course are modified continually to meet the new accreditation requirements by the Institution

of Engineers, Australia, and the aspirations of our students and the demands of the job market. The first step to review the contents was to survey local industries and our past students who have graduated in the last 3 to 10 years asking them whether the current contents meet their changing needs for the engineering workforce. Several topics were selected from several texts of operations research and management science and industries were asked to comment on their inclusion in the new syllabus. The topics for their consideration for inclusion in the new syllabus are shown in Table 1.

The authors paid special attention to local industries because a large proportion of our graduates are employed by them. In addition, they also sent the survey forms to the office holders of the local section of the Institution of Engineers, *Australia* to obtain their input and comments. The survey forms were designed and mailed out accordingly. Twenty five (25) out of the forty (40) sent out forms were returned. Most of the returns suggested the deletion of a topic, *Simulation*, and the addition of two topics, *Forecasting* and *Capacity Planning*. Suggestions to include software packages in the topics were also common.

The Faculty of Business of USQ offers three management science courses and they are tabulated in Table 2. This is another source of information for review. All of the courses are for the students of Bachelor of Business majoring in logistics and operations management. The first two courses are covered in the second year of the program and the last one in the third year. The authors reviewed the study books as well as the introductory book of the three courses. The study books have been

written by a senior lecturer in the Faculty of Business (Nooriafshar 2005a; 2005b; 2006). The quality of the study books is excellent.

By comparing the syllabus of MGT2100, *Management Science I* and MGT2102, *Management Science II* with that of existing ENG4004, *Engineering Management Science*, some content overlap was discovered. The synopsis *Linear programming and its application* of *Engineering Management Science I*, MGT2100 matches well with that of *Programming of Engineering Management Science*, ENG4004. The contents of the study books are not similar; in MGT2100, *Management Science I*, there is qualitative as well as quantitative treatment on the topic with great emphasis on how to use computer software, Solver in Excel to solve linear programming problems in business environment. The details of the quantitative treatment are not fully provided in the study book and students are required to study by themselves from the text book. In ENG4004, *Engineering Management Science*, the treatment is mainly quantitative and details of the treatment are supplied in the study book; students did not require a text book. No hand-on computer treatment is included.

The *Classical network models* of MGT 2100, *Management Science I* and *Project management* of MGT2102, *Engineering Management Science II*, are comparable to the *Critical path networks* of ENG4004. As in the previous discussion, the treatment of topics by MGT2100 and MGT2102 is both quantitative as well as qualitative but it appears to the authors that students have to refer to the text book for more details of the quantitative treatment. Moreover, the quantitative treatment made by ENG4004 is particularly deep as it includes costs analysis and bar charts in critical path networks, which is not commonly found in text books. This treatment enables students to

transfer the knowledge learnt to large and complex project management in the real world e.g. the building of infrastructure.

The contents of *Decision theory* and *Dynamic programming* of MGT2102 are similar to those mentioned in *Programming techniques* of ENG4004. The contents of *Introduction to Monte Carlo simulation* of MGT2102 are similar to those described as *Simulation* in ENG4004. However, this time the quantitative treatment of the topic in ENG4004 is deeper and with some examples.

By comparing the syllabus of MGT3103, *Production and Operations Management*, with that of *Engineering Management Science*, ENG4004, one can find that none of the topics are the same.

On the other hand, if one studies the topics for possible inclusion to ENG 4004, *Engineering Management Science*, one will find that two of the eight topics considered match the topics in MGT3103, *Production and Operations Management*; they are *Location, layout and job design* (method study and work measurement, facility layout and facility location model), and *Management of operations* (inventory management). It appears that if the syllabus of ENG4004, *Engineering Management Science* is changed significantly, then the contents of the two courses, *Engineering Management Science*, ENG4004 and *Production and Operations Management*, MGT3103 will be at par. This may be true if one investigates the topics covered in both courses. However, if one studies the details of the study books for both courses, one will find that the contents of ENG4004, *Engineering Management Science* are more quantitative while those of *Production and Operations Management*, MGT3103

tend to be more qualitative. This may be due to the fact that *Engineering Management Science* is for engineering students while *Production and Operations Management* is for business students. In conclusion, the courses from the Faculty of Business cannot be merged with that of the Faculty of Engineering and Surveying to reduce cost of study book preparation and course delivery.

The Faculty of Science offers two courses, MAT1200, *Operations Research I* and MAT 3201, *Operations Research II* to the students of Bachelor of Science in mathematics and statistics. The topics of the two courses are shown in Table 3.

After studying the study books of the courses briefly, the authors found that the contents of both courses are excellent. They also have deep mathematical treatment which engineering students will not be able to cope them with ease. The syllabus of the two courses offered by the Faculty of Science is for mathematicians or statisticians and is not for engineers. Because of the above reason, there is no need for the two courses of Faculty of Science to be merged with that of the Faculty of Engineering and Surveying (Wark 2003; Shi 2005).

### ***Courseware of other universities***

The courses to be studied by students in professional mechanical engineer programs were researched (University of London's website, undated; University of Manchester's website, undated, Dublin City University's website, undated;



Swinburne University of Technology Handbook, 2007; University of Sydney Handbook, 2007; University of New South Wales Handbook, 2007). Most professional mechanical engineer programs in United Kingdom consist of *Engineering Management* but not *Engineering Management Science*. The course offered by London's Global College (UCL), University of London covers the topics of Critical Path Network and Quality Control (UCL website, undated). The relevant courses of other universities are tabulated in Table 4, which shows that for most universities those courses contain *Critical Path Network* plus engineering management. In most instances, other courses relating to engineering management and industrial engineering are taught to enrich the management aspect of the programs.

### *New courseware*

After reviewing the survey form, the authors found that the topics to be preserved (in order of priority) include 1. *Critical path networks*, 2. *Programming* 4. *Quality control*, 5. *Micro-economic functions*. The only topic considered for deletion will be 3. *Simulation*. The topics for possible inclusion (in order of priority) are *Capacity planning*, *Reliability engineering*, *Forecasting and Inventory management*. One short topic is considered for deletion, and at most two topics can be added because of the teaching and learning time availability; these are *Capacity planning and Forecasting*. This can be achieved by trimming other parts of the preserved topics.

*Reliability engineering* is a good topic and may be added to 4. *Quality control*. However, there is no reason to add this to the course at this point in time because of

limited teaching and learning time and the electronic industry of Australia is declining. Inventory management is a worth adding topic but it is already a topic in a course, MEC3204, *Production Engineering* taught by the examiner. Figure 2 illustrates how, ENG 4004, *Engineering Management Science* is linked to other courses in the program of Bachelor of Engineering in mechanical engineering. However, MEC3204, *Production Engineering* is only taken by the students in the programs of Bachelor of Engineering (Mechanical) and Bachelor of Engineering Technology (Mechanical). Students from other programs will miss out this important topic. One possible way to remedy this is to persuade the respective heads of disciplines to include MEC3204, *Production Engineering* in their respective programs. It appears to the authors that there will be no reason to take the topic out of MEC3204, *Production Engineering* and include it in ENG4004, *Engineering Management Science*. Even if the authors would like to include the topic in ENG 4004, *Engineering Management Science*, the syllabus of the course will become too enormous for the teaching period. In addition to adding, deleting and trimming topics, the titles of the topics are also considered for a change. Initially, the authors agree to change 1. *Critical path networks* to 1. *Project management analysis*, 2. *Programming techniques* to 2. *Linear programming* and 5. *Micro-economic functions* to 5. *Financial analysis*.

### ***Enhancement of the contents***

Another important thing for the review of the course is to enrich the material of the contents taught. The first thing required to be done is to add popular computer

software to the contents taught so that students can solve engineering management science problems faster and easier. In order to improve the skills of our students in solving the problems of project management, the authors agree that *Microsoft Office Project Standard 2003* has to be included in the delivery of the topic, *1. Project management analysis*. The academic copy of the software is below 100 Australian dollars and it is anticipated that students can acquire the software at comparable price.

The authors also recommend using spreadsheet, e.g. Excel to solve some of the problems in the topics of linear programming – transportation and distribution, of quality control – control charts and of financial analysis – break-even analysis. To start with, the authors will solve one of the existing distribution problems in the study book of the course using the Excel Solver of the spreadsheet. Another software suggested for used is *Production & Operations Management – Quantitative Methods for Windows 3*.

### ***Assessments***

In S2, 2005, there were four assessments for the course, three assignments and one examination. Table 5 illustrates the lecturing and tutoring schedule and assignment due dates for the course. The first assignment deals with critical path network analysis (now project management analysis) with a weight of 10 %; the other two were for distribution method (linear programming) and control charts (quality control) respectively; each has a weight of 10%.

All assignments were marked by a part-time lecturer with a final check by the examiner. Suggested solutions with marking schemes were sent to students via WebCT on the due date of each assignment and no extension of assignments was permitted. External students handed in their assignments by mail via the USQ Distance and e-Learning Centre and were returned to them via the same pathway. Students are expected to spend four hours on each assignment.

The last assessment is a 3-hour open book examination which consists of five questions. The first question is a compulsory question based on *Critical path networks (Project management analysis)* and it contributed 280 of the total marks of the course. The other four questions covered the remainder of the topics; students were required to attempt any three of them; each contributed 140 of the total marks (Morgan, 2005).

Because of tight schedule for students to hand in their assignments, the authors decided to make slight modifications to the lecturing and assessment process. The proposed changes are shown in Table 6. The first thing that had to be done was to reduce the number of assignments from three to two without reducing the contents assessed. The reason for this is to give students more time to do the assignments after the knowledge required for the assignments has been delivered to and acquired by them. The first and second assignments are to be combined and now contain *project management analysis* and *linear programming*; the due date is now on the beginning of week 8, this is two weeks after the knowledge required for the assignment (now assignment 1) is delivered to students in the classroom. The percentage by weight of assignment 1 is now 20%. The third assignment becomes the second assignment and

it is about quality control. Its due date is on the beginning of week 12. All assignments are to be returned to students one week after they have been received and marked. This is to ensure that students can get feedback before the examination.

### ***Discussion***

It can be argued that USQ places more emphasis in engineering management science in her professional mechanical engineer program than similar programs in other universities researched, which usually emphasize more on engineering management and industrial engineering. USQ compensates engineering management and industrial engineering by offering *ENG3003 Engineering Management* and *MEC3204 Production Engineering* in her program respectively.

The addition of the software packages to the topics in the course will certainly improve the academic standing of it because its contents are now at par with most of international textbooks. Students will also be able to apply what they have learnt from the course to their workplace with ease as they will not need to do complicated iterations or calculations. All are done by standard software packages.

In addition to scraping *Simulation* from the current topics, the addition of the two new topics also brought about the deletion of *Decision Tree Technique* of the *Programming Techniques*, which was anyway omitted in many modern textbooks of Engineering Management Science.

The new arrangement for the assignments was implemented in semester 3, 2006. It was found that it was beneficial to the students because the marked assignment 2

could be returned to students at least two weeks before the examination. The examiner also found that his workload was slightly reduced because less administrative work was involved.

The addition of suggested solutions with marking scheme to the three sets of past examination papers will let the students know what are expected from the examiner and how the marks are allocated within each question. This will surely improve the performance of students

Up to now the total cost for the review of this course, ENG 4004, *Engineering Management Science*, is Australian dollars 17,595 which is in fact a small fraction of the annual income from the course. The course has an enrolment of 60 on-campus students and 60 off-campus students in semester 2 and an enrolment of 100 off-campus students in semester 3 in alternate years. The fee each student (for domestic students, the government subsidy has been included) will pay to USQ will be Australian dollars 2,050. The total income from the course per year is therefore =  $60 \times \$ 2,050 + 60 \times \$ 2,050 + \frac{100}{2} \times \$ 2,050 = \$ 348,500$ . This sum of money in fact is not paid by USQ because there is no time allocation to both authors by the University. They did the revision by their own initiative and in their own time.

In order to enable readers to compare the costs of reviewing this course with the living standard in their countries, it will be necessary for the authors to let them know that the average income of Australians in August 2006 was \$ 43,451 per annum (Wynhausen, 2006). The above cost is only for a certain part of the review. The final topics of the course have not been finalized and if this is to be implemented, the

Faculty would have to allocate 200 hours of work to the authors for the implementation of the review, as the case of other courses. To include Microsoft Office Project Standard 2003 in the delivery material of the topic of project management analysis, each author should get an allocation of 50 hours. To include spreadsheet in the delivery material of the topic of quality control and financial analysis, the authors will need to spend an extra of 40 hours. The rest of the possible allocated time is for inclusion and deletion of topics. In short the extra costs to USQ are shown in Table 8.

The authors claimed that 20 hours will be required for adding spreadsheet to the delivery material of each topic because a certain proportion of the material from the two books used by them contains errors and it took them some time to remedy it and transfer the method of solving the problems to existing problems in the study book of the course (Russell and Taylor, 2006; Anderson et al., 1994).

### ***Conclusion***

The review of the course has been fruitful as it reveals the topics to be added, deleted and modified to enrich the syllabus so that it meets the need of industry, the Institution of Engineers, Australia as well as the aspiration of the students. It is worth mentioning that USQ Engineering programs have been reaccredited by the Institution of Engineers, Australia for another 5 years. If the Faculty agrees to give extra time allocation to the two authors in 2007, it is envisaged that the whole process will be completed by 2008 delivery. The new courseware will benefit the employers of our

graduates, who are then better equipped with the engineering management science knowledge required by industries.

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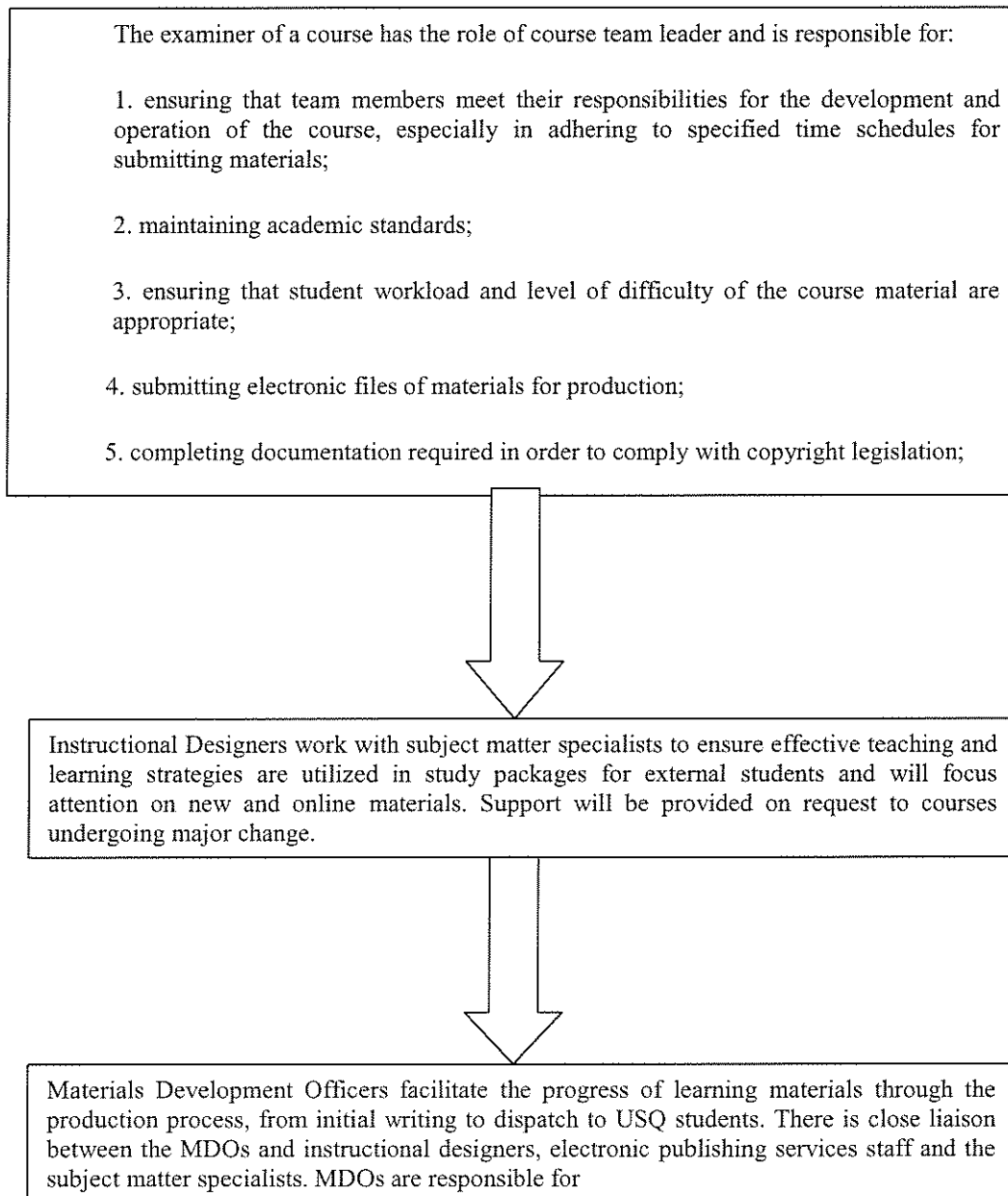
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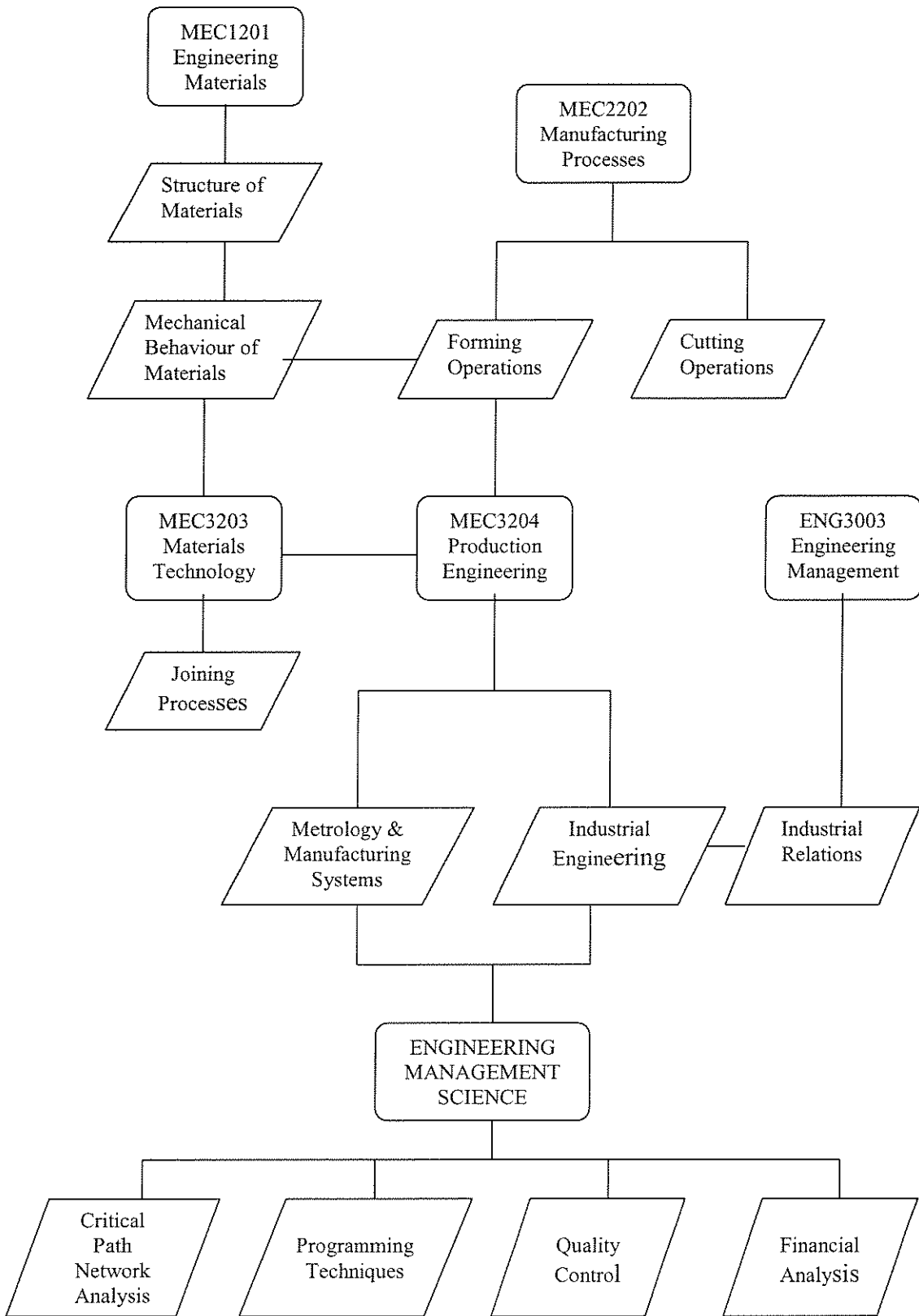
### ***Biography***

Dr. Harry Ku was trained as manufacturing engineer in the Hong Kong Polytechnic, University of Hong Kong and Swinburne University of Technology (Australia). He is a senior lecturer in USQ. His current research is in the manufacture of particulate-reinforced composites and microwave processing of materials.

Mr. Robert Fulcher, a senior lecturer, completed his degree in mechanical engineering at Darling Downs Institute of Advanced Education (USQ former institution) with distinction in 1977. He worked in operations and management of thermal power stations for 11 years before joining USQ. He also holds Master of Business Administration from USQ. He is also a Fellow of the Institution of Engineers, Australia.



**Figure 1: A flowchart illustrating the processes of design, development and production of a course.**



**Figure 2: Courses linked to 'Engineering Management Science' in USQ**

**Table 1: Existing and proposed topics in ENG4004**

Existing ENG4004	Possible topics for inclusion	Proposed ENG 4004
1. Critical path networks,	1. Facility location model	1. Critical path networks
2. Programming techniques	2. Forecasting	2. Programming techniques
3. Simulation	3. Waiting line analysis	3. Capacity planning
4. Quality control	4. Capacity planning	4. Quality control
5. Micro-economic functions	5. Reliability engineering	5. Micro-economic functions
	6. Facilities layout	6. Forecasting
	7. Inventory management	
	8. Work study and work measurement	

**Table 2: Three courses and their topics offered by the Faculty of Business**

Management Science I, MGT2100	Management Science II, MGT 2102	Production and Operations Management, MGT3103
1. Introduction	1. Project management	1. Introduction to Operations Management
2. Linear and integer programming models	2. Decision theory	2. Strategic decisions for operations
3. Applications of linear and integer programming	3. Dynamic programming	3. Location, layout and job design
4. Goal programming	4. Markov process/Brand switching	4. Management of operations
5. Classical network models	5. Queuing theory	
	6. Introduction to Monte Carlo simulation	

**Table 3: Two courses and their topics offered by the Faculty of Sciences**

Operations Research I, MAT1200	Operations Research II, MAT3201
1. An introduction to operations research	1. Deterministic inventory model
2. Introduction to linear programming	2. Probabilistic inventory model
3. The simplex method	3. Markov process
4. More on the simplex method	4. Queuing theory
5. Duality	5. Dynamic programming
6. Sensitivity analysis	6. Simulation.
7. Transportation and assignment problem	
8. Integer programming	
9. Networks	

**Table 4: Engineering Management Science of other universities**

Countries	Universities	Course title	Topics
Irish Republic	Dublin City University	Project and Quality Management Introduction to Operations Research	Critical Path Network <i>plus</i> engineering management Details N. A.
United Kingdom	University of London London's Global College Queen Mary College King's College University of Manchester	Management for Engineers Operations & Financial Management Project Management Industrial Management II Industrial Management III	Critical Path Network Quality Control <i>plus</i> engineering management Details N. A. Critical Path Network <i>plus</i> engineering management Critical Path Network <i>plus</i> engineering management Micro-economic functions <i>plus</i> engineering management
Australia	Swinburne University of Technology University of Southern Queensland	Engineering Management 2 Engineering Management Science	Critical Path Network <i>plus</i> engineering management <i>See Table 1</i>

**Table 5: Lecturing and tutoring schedule for day students, S2, 2005**

Week	Date	Lecture Topic	Tutorials	Assessment
1	18-22 July	<b>Introduction to Course:</b> <b>Project Management:</b> Introduction to Critical Path Method	✓	
2	25-29 July	Network Analysis	✓	
3	1-5 August	Charting Techniques	✓	
4	8-12 August	Cost Optimization	✓	
5	15-19 August	Project Management Software	✓	Assignment 1 due 22 August
6	22-26 August	<b>Linear Programming:</b> Distribution Method	✓	
7	29 August -2 September	Simplex Method	✓	
8	5-9 September	<b>Simulation:</b>	✓	Assignment 2 due 12 September
9	12-16 September	<b>Quality Control:</b> Control Charts	✓	
10-11	19-30 September	<b>Mid Semester Recess</b>		
12	3-7 October	Control Charts (Cont'd)	✓	Assignment 3 due 10 October
13	10-14 October	Acceptance Sampling	✓	
14	17-21 October	Acceptance Sampling (Cont'd)	✓	
15	24-28 October	<b>Micro Economic Functions:</b>	✓	
16-18	31 October -18 November	End of Semester Examination Period		3 Hour Open Examination

**Table 6: Lecturing and tutoring schedule for day students, S2, 2007 and beyond**

Week	Lecture Topic	Tutorials	Assessment
1	<b>Introduction to Course:</b> <b>Project Management:</b> Introduction to Critical Path Method		
2	Network Analysis	Week 1 lecture	
3	Charting Techniques	Week 2 lecture	
4	Cost Optimization	Week 3 lecture	
5	<b>Linear Programming:</b> Distribution Method	Week 4 lecture	
6	Simplex Method	Week 5 lecture	
7	<b>Simulation:</b>	Week 6 lecture	
8	<b>Quality Control:</b> Control Charts	Week 7 lecture	
9	Control Charts (Cont'd)	Week 8 lecture	Assignment 1
10-11	<b>Mid Semester Recess</b>		
12	Acceptance Sampling	Week 9 lecture	Assignment 2
13	Acceptance Sampling (Cont'd)	Week 12 lecture	
14	<b>Micro Economic Functions:</b>	Week 13 lecture	
15	<b>Revision</b>	Week 14 lecture	
16-18	End of Semester Examination Period		3 Hour Restricted Examination

**Table 7: Costs involved in the review of ENG4004, Engineering Management Science**

Person	Salary/ hour (\$)	Time spent (hours)	Cost (\$)	Overhead (\$) #	Total cost (\$)
Examiner	37.24	92	3,426	7,082	10,507
Moderator	41.56	9	374	773	1,147
Instructional Designer	35.08	5	175	363	538
Material Development Officer	19.68	25	492	1,017	1,509
Computer Operator	15.87	50	794	1,640	2,434
Printing Staff	15.87	30	476	984	1,460

**Grand total 17,595**

#In USQ, overhead is estimated to be 2.067 times the costs.

**Table 8: Further costs involved in the review of ENG4004, Engineering Management Science**

<b>Person</b>	<b>Salary/ hour (\$)</b>	<b>Time spent (hours)</b>	<b>Cost (\$)</b>	<b>Overhead (\$) <sup>#</sup></b>	<b>Total cost (\$)</b>
Examiner	37.24	150	5,586	11,546	17,132
Moderator	41.56	50	2,078	4,295	6,373
Instructional Designer	35.08	10	351	726	1,077
Material Development Officer	19.68	45	886	1,931	2,717
Computer Operator	15.87	85	1,349	2,788	4,137
Printing Staff	15.87	100	158	327	485
<b>Grand total</b>				<b>31,921</b>	

<sup>#</sup>In USQ, overhead is estimated to be 2.067 times the costs.