SUBMITTED ABSTRACT

Strengthening a Syllabus Without the Cost of High End Modern Technology or Applications

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Not every mechanical engineering department can implement an undergraduate programme that exposes students to cutting edge technology or applications such as nanotechnology. This paper therefore discusses other ways to strengthen a syllabus, to prepare students for employment or further study in a fast changing world, whether intending to work in such cutting edge fields or the more traditional mechanical engineering activities. Three main themes are discussed. Firstly the syllabus overall structure can be set up to balance the core subject areas that are still relevant with a suite of electives which can more readily be changed to reflect the modern applications which can be supported, as and when that may be. Secondly, project led teaching methods can be blended into a range of subjects to develop the students truly independent learning skills and to allow for an experience termed "reverse education". Thirdly, professional engineering skills can be emphasised and work experience can be more formally set up and used to prepare the student for employment as well as to move them away from being a "text book engineer". These changes, amongst others, have already been implemented in a syllabus, with a mix of success, possibly due to staff undergoing a learning process themselves in how to get the best out of some of the changes. It should be noted however, that the observations are based on a small statistical group.

AUTHORS INTERPRETATION OF THE PURPOSE OF THE POSTER

The above abstract was accepted for a poster, and hence its content is given in a format to facilitate discussion during the poster session.

Comments are welcomed at anytime through any means from conference participants, not just on topics directly related to the poster contents, but on any other matters.

Electronic copies of the poster can be made available directly from the author, if not included in the conference proceedings.

Please note also the information on page 8, including contact details.

INTRODUCTION

The professional community continues to research and develop mechanical engineering syllabi to meet the changing demands placed on the discipline. There seems to be a consensus that the discipline is being driven by the need for:

- Emerging sub-disciplines.
- Merging of traditional disciplines.
- New applications of the core fundamentals.

These topics include medical and bio-engineering, new scales of engineering such as nanotechnology or micro electrical mechanical systems, mechatronics and others. Engineering has an ever more important role to play, not just for business and economic reasons, but for society on a global stage. Mechanical engineering has a strong future, given there will always be a need for interaction between solids and fluids, with considerations of materials, statics, motion, forces, energy and so on. It is just a question of the detail of the end use or application, and the management of continuous change, professional responsibility, changing political agendas and topics such as sustainability.

These topics such as nanotechnology may well represent the future needs and hence define the purpose of much of the mechanical engineering discipline, and the academic and professional community should therefore plan, implement and carefully manage a continuous change process. However, it may not make sense for all departments to follow the same plan, or the same timing even if the principle of the plan is the same. The full spectrum of industrial and academic needs of graduates needs to be considered. Not all departments may be able to make the changes for a variety of reasons including academic and non-academic staff training, experience, skill set teaching and research interests, not to mention affordable and available equipment. There will inevitably be competition between departments to gain quality human and other resources, hence not all departments can lead the way with change. There will therefore be a time lag before every department can make such changes, and could only be achieved for all departments, if all departments want to make the changes, once the cutting edge syllabus content has become "base" rather than "emerging" or "pacing", to use an analogy with the "S-curve" innovation theory. By that time, the cutting edge has moved on again. All departments have an equally important role to play, as the overall system of innovator and follower cannot be sustained or optimised without mutual recognition and co-operation.

Therefore, we must not lose sight of continuous improvement of other areas of the programme, and this is the focus of this poster.

Three themes are presented, briefly giving the rationale and changes effected. These changes have been introduced into a very young department with low student numbers, meaning there is no in depth statistical basis of proof. There is however confidence in the relevance of the observations based on having a very close contact with the small number of students throughout their degree. Giving students such high access to staff, almost like a client consultant relationship, is in fact one of the best ways to provide a very high level of added value for each student. This is not viable for most departments, so is not presented as one of the themes.

THEME 1 – SYLLABUS STRUCTURE

Rationale

- Flexibility to rapidly change advanced courses to meet changing demands as and when possible.
- Solid traditional foundation reflecting continued need for ME core into the future.
- Improve the flow of development of skills, knowledge, maturity and so on from intake to graduation.

Syllabus template

- 1st year: Sometimes have to use some of the 1st year to bridge the gap between school and preferred level of maths and sciences, as well as introducing some basic engineering courses and computing skills.
- 2nd year: Core traditional courses such as materials, mechanics of solids, dynamics, vibration, thermofluids courses, design, all or most with some content of computer modelling or packages as "tools".
- 3rd year: Complete the core courses and start some electives. The electives provide the main method of syllabus flexibility, and there could be various types in terms of classification or rules for selection or even who selects them, teaching methodology (see theme 2), emphasis between technical deepening and developing skills.
- 4th year: Mostly electives and an individual main project.
- Mandatory work experience (see theme 3).
- Add in a balance of humanities, social sciences, business and other broadening courses.

Some specific examples

- Chemistry, 1st year mandatory course: Used as a foundation for basic chemistry of materials and possibility of advanced courses in the emerging cutting edge discipline areas. Could include example applications linked to the cutting edge application as a point of interest for the students, who might take such courses in two or three years time.
- Fundamentals of Electrical Engineering: Traditionally used to give the basic understanding of, for example, a Wheatstone bridge circuit or interfacing sensors with different voltage ranges to data acquisition units and so on. Could be a primer for Mechatronics or MEMS courses if they come on line.
- Department Special Topic (DST), elective: Subject description given as "Selected topics of current interest to the department and not covered by existing courses, allowing for the possibility of taking advantage of rare opportunities at very short notice." A very fast way to implement change and run a highly topical or innovative course if the opportunity arises.

THEME 2 – TEACHING METHODOLOGY AND SUBJECT STRUCTURE

Rationale

- Move away from "chalk and talk", to a more stimulating and effective learning environment for both students and staff with at least not incurring any time or resources economic disadvantage, and perhaps gaining advantage.
- Preparing the student for the work place or further study where strong independent and lifelong learning skills are expected. Further aiding the transition from a school student to a professional engineer (see also theme 3).

Contributing elements

- Project led engineering education (PLEE): Definition "Project-led engineering education focuses on team-based student activity relating to learning and to solving large-scale open-ended projects. Each project is usually supported by several theory-based lecture courses linked by a theme that labels the curriculum unit. A team of students tackles the project, provides a solution, and delivers by an agreed delivery time (a deadline) a 'team product', such as a prototype and a team report. Students show what they have learned by discussing with staff the 'team product' and reflecting on how they achieved it. The subject of each project exemplifies the theme, and is appropriate to the levels of competencies in the programme at the time it is carried out. A series of projects explores different subjects and themes and develops increasing levels of professional competencies. In this way, the students learn to master the competencies specified in the curriculum (knowledge, skills, and attitudes) within the context of professional practice". Taken from Powell., P and Weenk, W., "Project-Led Engineering Education", ISBN-90-5931-157-4, Lemma Publishers, 2003.
- Real work environment: Operating by meetings, defining roles and responsibility, objective driven, identifying the bigger picture (instead of the business case, the motivation for study),
- Reverse teaching: Analogous to reverse engineering. Starting with the end result of a case study, perhaps taken from staff research or consultancy, and work backwards identifying the required element for the success of the work, whether technical, managerial or other, and end up with a detailed breakdown. Then start at a logical place on that list and cover topics with the students, perhaps by a mix of traditional lectures and setting the students some private research work. More suited to elective courses and more mature students.
- Blended methods: Maintain a balance of a mix of the traditional and the modern methods, optimised to various constraints as well as to give a breadth of experience of adjusting to different methods and develop an ability to pull out from that experience what is required.

THEME 3 – PROFESSIONAL ENGINEERING SKILLS AND WORK EXPERIENCE

Rationale

- Engineering as a profession versus an academic discipline.
- To provide greater motivation and relevance for their studies, exposing students to real engineering problems and projects.
- To enhance awareness of business, legal, management, culture, community and other wider issues. An example of ethics that relates back to their learning motivation, is given by encouraging the student to develop as an effective professional engineer which would automatically lead to high marks, rather than focussing on how to get more marks that may not necessarily lead to being a better engineer.
- Preparing the student for the work place or further study where professional engineering skills are required or expected. This would include time management, emphasising learning curves, monitoring progress and being self critical through review cycles and setting targets, identifying learning outcomes, conducting meetings and other forms of verbal or rapid communication.
- To literally have "experience of work", meaning what it is like to have a boss, or having to work solidly for eight hours a day, five or six days a week for eight to twelve weeks, or having real responsibility and less direction or support, having to manage work colleagues relationships, developing discipline and so on.

Inclusion in a syllabus

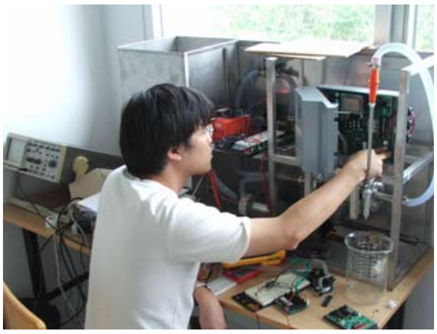
- Monitored Professional Development course: Mandatory work experience with a minimum of 480 hours, fully documented through a formalised setting up, specifying, monitoring reporting and feedback process. Ending in a collection of reports by the student and about the student from the company or institution. Normally carried out during the summer break, with staff overall supervision and input to the next segment of work experience as well as sourcing industrial support. Requires time and energy to establish, but if reaches a critical mass, it could be self sustaining and encourage increased industrial collaboration at other academic levels and interest to staff.
- Professional Engineering courses: Three single credit courses, aiming to promote a sense of professional discipline, awareness of the profession's activities and purpose as well as specific skills such as report writing, time management, meetings, dealing with other professionals, presentations, writing a resume, negotiation, change management, managing people in organisations and project management. The courses would also expose students to institutional meetings, site visits and other eye opening value added events.
- The Professional Engineering theme can be emphasised informally in every course the student takes and in their contact with staff, their conduct on a day to day basis and what is expected of them in terms of being pro-active. This requires a conscious effort by staff as well as staff with a PE background themselves.

EXAMPLE SUCCESSES

It would not be fair to claim that the following example successes have come about purely because of the above changes or additions to the syllabus. The students may well have achieved success without it. Example activities and results are listed below.

- A final year student has negotiated support from a company, with a project budget of 100 K Baht to improve the efficiency and reduce production cost of a fluid filling system.
- Initial test results of a current final year project suggests that the fuel bill for a specific grain drying plant could be reduced by as much as 1/3.
- A previous final year project performed an FE analysis of a new passenger ferry hull linked to a marine design consultancy company, publishing a paper at a national conference.
- 2nd year Engineering Research Methods (ERM) course produced a simple condition monitoring test rig and test method extended to university plant equipment, also publishing a paper at a national conference.
- Attendance at several professional engineering institutional meetings has given the students a much broader vision of the activity of senior engineers and executives relating to national level engineering projects. This has had a drip feed effect on the student's, and allowed them to set their sights a lot higher, rather than just look ahead to their next timetabled class or completing academic work by the end of their current semester. It has also exposed them to a much broader range of personality, different interests, level of thinking, such as the link between engineering, business and politics.
- DST elective (see page 3): PLEE and an element of reverse teaching applied to a management and technical specification project. A learning environment that was a shock to the students and difficult for them to adjust to. Learning outcomes included reflection on their own learning skills and processes, as well as the actual content relevant to the project.
- MPD course (see page 5): Although the students found it initially difficult to use the documentation for quality control of the course, and sometimes found it difficult to interface this documentation with existing company systems, the end result has been promising. Benefits have been seen from technical knowledge, project management, self criticism in terms of identifying a shortage of skills or knowledge and redirection towards new experiences, and being able to achieve something of value to the company.

Condition monitoring of university plant equipment, ERM project



Final year student testing his prototype fluid filling system

POSSIBLE FURTHER DEVELOPMENT

- In general, apply the principle of continuous improvement with review cycles based on the academic year with regular feedback from staff, students and industry in the case of work experience. Aim to strengthen current themes and eliminate causes of any failures without prematurely concluding that the idea was wrong – give it a chance.
- Input requirements into future staff hire and encourage awareness of industrial and education trends and professional development of current staff, such that these initiatives can be properly developed, resourced and delivered on. Make sure that department policy reflects the principle of the themes and staff give the same message to students as a unified front in all aspects of what they do.
- Much of the above has been implemented into year groups two to four, with the first year common to other degree programmes. It is intended to develop some aspects of these themes in the first year. This represents an organisational problem, which may be common in other institutions, where cross disciplinary or inter department course have benefits but also possible drawbacks.
- Improve the choice of electives, including the option for "minors" and add the high end modern technology content when possible.
- Continue to evolve teaching methods and facilities, such as providing a lab and design or computing studio environment where students naturally want to spend time there on project work, or prototyping, inventing, exploring, using online tutorials to cover the basics of a new computer package, and so on.
- Work towards professional institutional meetings that are more accessible to the local region (currently have to travel 150 km), supporting networking relationships between students, staff and industry which are more focussed on developing links relevant to industry and academia. Currently professional networking mechanisms in the region are not specifically set up for this purpose, and although very valuable, are not as efficient as they could be from an education point of view.
- Build on the MPD course aiming for full industrial sponsorship with a guided application process for students as part of their application to study in this department. This would be based on the MPDS model used by the IMechE, from which the MPD course is a first step along the evolutionary path. A full sponsorship system needs a certain critical mass and track record in order to launch the business case to a sufficiently large number of companies, who would form a consortium-pool with agreements linked to this department.
- Link the programme and staff activities ever more closely to industry, in everything that we do. This could include more special guest lecturers or seminars from industry, teaching through doing or student research and consultancy participation.

ABOUT ASIAN UNIVERSITY MECHANICAL ENGINEERING DEPARTMENT

- A relatively new department with our first graduates in 2004.
- Located on the door step of Thailand's Eastern Seaboard, known as the "Detroit of the East". The Eastern Seaboard has many engineering sectors outside of the automotive industry, and continues to grow at a healthy pace.
- A blend of cultures, but emphasising international standards and professional training for work related issues.
- Welcomes applications from overseas students for study, including summer internships.
- See also http://wwwedu.asianust.ac.th/~me/

AUTHOR'S INTERESTS

- Engineering education: trends, policy, globalisation & collaboration, engineering as a profession versus an academic discipline.
- Professional engineering institutions: student involvement, collaboration and unification, their role and responsibility in modern society.
- Blurring the boundaries between industry and academia: student & staff projects, work experience, sponsorship, exchange, research, consultancy, entrepreneurship, seminars, workshops.
- Technical interests: impact and vibration engineering.
- Opportunities to work on challenging projects related to any of the above, through a mixture of collaboration on grant proposals, consultancy or other means.

ACKNOWLEDGMENTS

The author is most grateful to the Institution of Mechanical Engineers U.K. for the award of a "Thomas Andrew Common Grant" towards conference expenses.

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