Full Paper

Background

Many employers' organisations, industry practitioners, and academics recognise that engineering education is in need of reform to meet the ever increasing complexities and challenges of today's world. Teaching engineering in specialist swim lanes isolated from the essential professional skills of the 'real' world is outmoded and places engineers at a disadvantage when it comes to competing for board room appointments against other professions. "In modern society, engineers are increasingly expected to move to positions of leadership, and often take on an additional role as an entrepreneur" Crawley (2011).

Employers continue to be frustrated at the effort required to convert a new graduate into a 'fit for purpose' professional engineer. Industry led professional development, post-graduation, can be a mixed bag, largely dependent on the company and the personalities involved. Like golf, bad habits can develop at an early stage in a profession and may take many years to correct.

With a growing awareness of these issues The Royal Academy of Engineering set up a Visiting Professorship scheme. As part of this scheme a 'systems approach' was introduced into the curriculum together with a series of ever challenging 'systems scenarios' by the author at University College London (UCL) in collaboration with the faculty departmental leadership team during the period 2004 to 201. These scenarios provided students with a representative, 'fast forward' experience of a major project. Feedback from staff and students showed this was a popular and successful programme, Robinson (2011). This led the author to develop a similar initiative at The University of Auckland (UoA). This time covering an entire engineering faculty. The aim was, and continues to be, to change to the way engineering is taught at Faculty level and this practical demonstration of a new approach was considered the best way of convincing other faculties to follow suit.

A strategy for introducing systems thinking, including professional development, was developed in 2010 to form the basis of the programme. The first step was a full scale scenario 'systems week' for all 535 Part 4 engineering students in 2011, using 'The Reconstruction of Christchurch' as a topical project following the devastating earthquake of February 2011. Students of all engineering disciples participated, working in teams of 25 to:- understand the stakeholders and the 'problem space', develop options for a city-wide solution, describe their best fit design together with an implementation plan, risk register and their recommendations for the way ahead. Each team prepared a comprehensive report and gave a 3 minute presentation to a surrogate prime minister. Lectures on 'systems' were given, but all other lectures and tutorials cancelled for the week. Despite misgivings from some in the faculty that students with no real experience of leadership could cope with the challenge of managing a 25 person team tasked with the enormity and complexity of the scenario, the students, who barely knew each other, collaborated and cooperated with a level of enthusiasm and energy that took the faculty by surprise. Motivated students worked long hours to achieve high quality outcomes for the solutions and reports presented.

Purpose and Goals

The overall purpose of the initiative was to create an exemplar professional development programme and demonstrate that it can be set up and delivered successfully in the challenging environment of a large, traditional, engineering faculty - thus providing a proven template that other Universities may follow. To achieve these objectives the goal was to design, develop, deliver, and prove a complete programme of teaching content which would form an 'application' layer within the standard undergraduate engineering curriculum. 'Systems thinking' was adopted as the framework for connecting leadership, design, project management and business practice. The programme would also provide a series of systems scenarios representing large, 'complex' projects. Here students would apply the theory by participating as a member of a large multi-disciplinary team.

The goals were:-

Students: To enable students to gain knowledge and skills beyond the purely technical - so they may graduate as 'well rounded' engineers capable of accelerated career paths as well as having the ability and confidence to compete with other professions for top jobs. In addition, the programme would give each student the opportunity to explore latent talents, and demonstrate and grow their potential as a future leader and as a professional engineer.
The faculty: To demonstrate the faculty could adopt an entirely new approach without impacting current engineering teaching whilst bringing benefits to students, to update the systems engineering part of the curriculum, and to broaden business and professional skills. The programme would help the faculty meet the latest requirements of the Washington Accord, and also enhance the reputation of the faculty and give it a more competitive edge.
Industry: To provide industry with graduates who were more in tune with the needs of the work place and had demonstrable skills in: working in multi-discipline teams, leadership potential, understanding and working with the needs of stakeholders, sustainability, cultural diversity, ethics and other aspects of engineering professionalism.

A key theme of the 'systems' initiative was to recognise that success in engineering is just as dependent on leadership, people and communications skills as it is on pure technical competence.

Approach -To meet the goals, these **innovations** or '**policy'** requirements were established:

a. ***teaching an integrated 'systems thinking' approach***
providing a structured methodology and framework to link key themes in - managing a design, a project, and a business. In different ways, these also include disciplines such as leadership, understanding stakeholders, requirements, options, ethics and advocacy, advanced communications, finance, innovation and entrepreneurialism

b. ***'constructivist' - project based learning - learning by doing***
embedding the 'theory' by including a fast forward experience of a major project, an organisation, or a business – an 'application- led' approach to the teaching of professional skills throughout the four years of the undergraduate course

c. ***working in teams for project work comprising multi- engineering disciplines***
hands on experience of how: to understand and work with others; to behave with others in a large team and be a successful contributor; to develop leadership, respect, and motivational skills; to unleash the hidden capabilities of oneself and others.

d. ***developing thinking skills - no templates or worked examples***
much of engineering educational is procedure driven, with students depending on worked examples, previous exam papers, and model answers. Whilst a professional engineer will need to comply with certain standards and procedures, e.g. on safety, a seasoned engineer needs to also draw on ingenuity and thinking skills; particularly with 'new' projects where there are no "templates". Therefore templates were avoided wherever possible to develop thinking skills. The need to think clearly and make sound judgements is a dominant theme in the entire systems approach.

e. self determination
to underpin the ability to think, make decisions and apply leadership skills, students are required to take ownership and accountability for their work. They have to analyse the problem space and make judgements about the best fit solution and how that might best be presented to an executive audience. To gain insight into the qualities of good leadership each team selects its own project managers and leader, giving students the

opportunity to examine their own capabilities, maturity and ambition before applying.

Implementation

The main principles had been demonstrated in the 2011 Part 4 project 'The Reconstruction of Christchurch'. In early 2012 the author joined the faculty and implementation began. By July 2013 the fully integrated approach across all four years was approved by the faculty. The transition to the new programme was completed in 2014 and this included the full rollout of all the developed content which was organised over 4 years:

Part 1 'Principles of Design'

Part 2 'Managing Design and Communications' (managing design = systems engineering) Part 3 'Managing Innovation and Managing a Project'

Part 4 'Managing a Business'

The structure was carefully integrated across all four years so that the basic principles taught in the first year were reinforced in subsequent years. Additional layers of detail were added each year and case studies became increasingly more complex. This 'longitudinal' structure allowed a student's professional development to progress seamlessly throughout each successive year of the four year course and to replicate a typical career path, providing further evidence of the benefits of an 'application led' approach.

Teaching hours which had been dedicated to 'professional development' were rationalised and re-organised to allow for teaching the systems led approach.

Content (see tables below)

Previous teaching of professional development in the faculty had lacked cohesion and flow. Historically, professional courses had been criticised by students as being a series of ad hoc lectures with no flow and bearing little relationship to each other, particularly year on year; there being no overall 'ownership' of professional development in the faculty. Systems thinking, the components of which are widely recognised as best practice by individual practitioners and industry, provided the basis for developing a fully integrated framework for all aspects of the course. The systems thinking content and the lecture schedule was structured to support each scenario. In turn the scenario content and the deliverables were specifically aimed at reinforcing the principles of systems thinking – an integrated approach to 'learning by doing'. Some scenarios required some specialist input, e.g. resilience (2013).

Part 1 'Principles of Design'
- The Design/ Systems Life Cycle
- A stakeholder analysis
- A requirements specification
- Creation of design options
- Trade off analysis leading to "best fit" design
- "best fit" system architecture
- The importance of test and validation
- The cost of modifications
- Leadership and team work

Part 2 'Managing Design and Communications'
- Why systems fail
- More detail on the design / systems lifecycle
- Advanced systems architecture,
- Command and Control and Management Information systems
- More advanced concepts for test, validation and integration
- Cross systems issues such reliability, maintainability, resilience, security
- Health and safety,
- Sustainability
- Cultural Diversity
- Risk and opportunity
- Advocacy
- Effective communication skills Leadership and team work

Part 3 'Managing Innovation, Managing a Project'

- Why Projects fail
- Project Life cycle
- The project plan
- Estimating and finance
- Monitoring and control
- Project Risk and Opportunity
- Project operations
- Sustainability
- Innovation
- Entrepreneurship
- Ethics
- Leadership and team work
- Leadership models Vs Management models

Part 4 'Managing a Business'

- Why businesses fail
- Business life cycle
- Principles of business
- Preparing a business plan as an entrepreneur
- Reviewing a business plan as potential investor
- Preparing a business case
- Managing change
- Enterprise architecture
- Transition to work
- Business ethics
- Engineering and the Law
- Business risk and opportunity
- Managing Communications
- Advanced Leadership and team work

Application-led Systems Scenarios

To achieve the goals, systems scenarios were introduced as a core component in each part of the course, providing a representative experience of a major project and demonstrating the key professional principles required for success. They were designed to stimulate interest and provide a multi-disciplinary approach so that all students felt engaged, regardless of their speciality. Over 15 Scenarios of national or regional significance were developed and delivered. They increased in their scope and complexity, year on year, and included:

Part 1

1. Hospital design
2. The Americas Cup Venue
3. Museums in a Digital Age
4. A National Engineering Exhibition

Part 2

5. A Town Planning Model for Auckland
6. The Closure of Symonds Street
7. An Airport design
8. Extending Auckland's Container Terminal

Part 3

9. Southern Bus Way
10. A Theme Park Design for Christchurch
11. Managing a Movie

Part 4

12. The Reconstruction of Christchurch
13. Harbour Bridge
14. A Resilience Architecture for Auckland
15. Reengineering Enterprise NZ

In places, the scenario 'brief' was deliberately seeded with errors and conflicting statements (as in the 'real' world). It was brief, providing a broad context and the possibility of a range of outcomes, and it deliberately fell short of a 'requirement'. Each scenario was different so that it was not possible for students to use a previous year's report as a "template". The aim was for students to think about the 'problem space' as well as the 'solution space'. There were no right or wrong answers. Marks were awarded for the quality of the team's thinking. Creativity, innovation and an insightful, professional approach attracted additional marks. The ability to analyse the problem space is an essential skill, as is use of structured 'system thinking' methodologies where the aim is to find a 'best fit' solution to a complex scenario. Emphasis was placed on the needs and aspirations of community and business stakeholders and the practicalities of multi-disciplinary projects, team work and leadership. The impact of ethics, cultural diversity, sustainability and health and safety were also given prominence throughout the course and they all featured as key deliverables in the scenario reports. This provided appropriate knowledge and skills for the future workplace and career development, as well as demonstrating full compliance with the Washington Accord.

Logistics and responsibility

To provide increasing challenges in teamwork, team sizes increased with 4 or 5 in Part1, 12-15 in Parts 2 and 3, and 25 in Part 4. Scenarios during Part 1 to Part 3 were not run as a dedicated systems week. In 2011 there were 535 Part 4 students, and as numbers in all year groups increased to over 700 logistics became more complex. Students were placed in their systems scenario teams by teaching staff based, wherever possible, on capability, discipline, gender and ethnicity. The aim was to ensure each team was balanced and not dominated by any particular discipline or social clique. Often students allocated to a new team would not know their team mates. This again replicated life in industry where acclimatising and adapting to new teams on a regular basis is common. All this was part of the 'application-led' approach. Faculty staff acted as tutors and coaches to help advise students – using reflective coaching techniques – but they did NOT participate or provide an answer. It was important students fully understood the problem space and took responsibility for their own affairs. They had to make difficult decisions and sound judgements based on imprecise information. They owned the solution and the report – not the staff.

Ingenuity and Thinking Skills

Systems thinking methodology specifically tasks students with creating a wide variety of options before determining a 'best fit' solution via series of trade-offs. The focus on options provides a stimulus for creativity and teaches that a premature decision on a single solution is often suboptimal. In the scenario staff actively encourage original thinking and an unorthodox approach, provided it can be justified. This led to a variety of solutions, for example in 'The Closure of Symonds Street' solutions ranged from installing new railings to a complete new by-pass. Students often anecdotally commented "the scenarios provide the only opportunity for creativity in the entire undergraduate programme".

Team working

The scenario provided a 'hands on' lesson in leadership and team work clearly showing the need for effective communication at all levels of an organisation from workers, middle managers, executives leaders, board members, to investors/stakeholders. The team leaders decided on roles and responsibilities, allocated tasks and monitored the progress required to meet quality standards and deadlines. To complete this 'application led' learning experience in teamwork, communications and professionalism, all students needed to contribute as part of a well-coordinated team, brainstorming, sharing and testing ideas, making informal presentations, progress reports, progress meetings and 'one to one's. To complete the scenario to a reasonable level (and attract high marks) close cooperation is essential.

Deliverables – examples include:

1. Executive summary
2. Conclusions
3. Recommendations
4. Stakeholder analysis
5. Requirements
6. Design options
7. Trade off analysis
8. Best fit design / systems architecture
9. Test and validation strategies
10. Risk and Opportunity
11. Impact of cross systems issues eg reliability, maintainability
12. Cultural diversity, ethics, sustainability, Health and safety
13. Project plan
14. Managing change (as the new project comes on stream)
15. Business case
16. Appendices

Each scenario generally followed the systems thinking 'life cycle' but was modified and adapted to suit the aims of the scenario and the learning outcomes required. Although not research projects, scenarios required students to do some investigative work to gain familiarity with the application but this was deliberately different from the laboratory experience in other parts of the course. Also, the style and form of the scenario report was aimed at an executive audience, unlike technical reports which are aimed at a research /specialist engineering audience.

Student assessment

Throughout the course students were assessed using assignments, tests, and examinations to monitor their progress towards their learning objectives. As the course has developed - a student's capability, rather than their knowledge, has become the measurement of their progress and achievement against learning outcomes. It has become a question of 'what can you do' rather than 'what can you memorise'. In exams and tests, for example, students could be asked to consider a familiar scenario, not covered on the course, and prepare a detailed stakeholder analysis, a plan to manage change, a risk register or a project plan.

With this kind of 'constructivist' course there is always scope for some subjectivity particularly where the policy is not to have right or wrong answers. Marks were awarded on the quality of the thinking. Given this approach, and the number of students on each course, the assessment process required special attention. Assignments, tests, and examinations were usually marked by teaching assistants who attended briefings and workshops to ensure there was a common view of how students' answers should be interpreted against a marking rubric. They were provided with a range of potential answers to help them determine the difference between a good, well thought out response and a poor one. Quality checks were made by senior teaching staff during the exercise to ensure, wherever possible, a consistent standard was applied across the range of all students and groups.

The systems scenario reports required more expert interpretation and these were marked independently, as if they were the client, by two senior systems teaching staff with many years industrial experience at executive level. Reports were typically 150 pages but could sometime swell to over 300 pages. Reports of this length for a complex project would be quite typical in industry. Each deliverable (there could be as many as nineteen in each report) was marked on its own merits, and aggregated to form a total group mark. There were no 'model', or right or wrong answers. Marks were awarded for quality of thinking and the structure, quality and flow of the report. Were the arguments well-structured and clear? Overall, was the report compelling and convincing? Marks were added for creativity, flair and an insightful, professional approach. Inevitability, the resultant document also became a reflection of leadership, teamwork and effort. Well run, well-motivated, teams applied maximum effort and it showed in the quality of the final report.

Peer assessment

With final year group work deliberately organised in large teams (up to 25), a unique peer assessment process and software tool was developed to derive a mark for an individual's performance in the group. When the scenario was completed students submitted an on-line questionnaire. Effectively, they rated each other's contribution to the project. A key principle was that all students take part and that all their inputs were guaranteed confidential.

Feedback to students

Personal feedback was a challenge with so many students (535 -700), and particularly for group work, where students wished to know how their own contribution fared in the marking. To provide a measure of feedback an open-day was held where all reports were displayed with red, amber, green, colour coding against each deliverable as well as the overall report so students could compare their work with others. Teaching staff were on hand to answer questions and opening times were extended or repeated. This form of feedback was seen as more powerful than handing back a report with comments because students saw the full range of submissions and learnt accordingly. Some industrial organisations follow a similar method where, at the close of a competition, all proposals are made available to all bidders who use this as a valuable learning exercise to view the relative strengths and weaknesses of their proposals vs the 'winner'. Everybody learns, and the same is true of students – a typical anecdotal response was "we thought we had submitted the best report as we all worked really hard on it, we were very disappointed with the mark but now we have seen the top reports we can understand why". Teaching staff have noticed that each year the performance of a cohort improves and some of that may be attributable to this style of feedback. Not all students attend the feedback session in the same way that not all students attend lectures. Some teams send representative who report back to the team. The leaders and the more dedicated team members do, and attendance at these feedback sessions has grown year on year.

Evaluation of the programme

On-going student surveys, informal contact between students and teaching staff, and consultative groups set up for each semester, continued to provide input to a continuous improvement process where key lessons were learned, and content, delivery and course administration were updated. For example, following consultation, lectures were recorded and distributed electronically, the peer assessment survey was delayed until after systems week so that students could spend more time on it without the pressure to reduce effort on the project itself, feedback on reports was improved and this led to the colour coding scheme. Based on feedback and lessons learned, lecture content was rescheduled so that it appeared more logically in the timetable and some content was presented in more detail e.g. cross system issues. Also, accommodation during systems week was dramatically improved over the years so that each of the 25 teams now has a dedicated space for the week.

Discussion

The programme demonstrates that it was possible to provide an exemplar 'application-led' professional studies course based on systems thinking methodology, and to implement a step change at a faculty level, across all disciplines, delivering a fully integrated, constructivist professional development course, which evolved 'longitudinally' over 4 years. Although the systems scenarios themselves took on a consistent form to mirror key systems thinking principles, the complexity and the challenge of managing larger teams and a larger scope escalated year on year. The application and longitudinal approach reflects progress through a typical career, and prepares students for their longer term professional careers.

Students

Since the week-long 'systems scenario' in 2011, over 3000 students have graduated. In spite of initial reservations and 'opposition to change' in early years the student response, by the end of academic year December 2014, was overwhelmingly positive as the table shows.

Student Feedback statistics 2014 569 students surveyed >95% response	Stongly agree	Agree	Neutral	Disagree	Strongly disagree
I would recommend this course to a colleague	20	48	22	6	4
I feel this course has been of real benefit to me professionally	32	50	13	4	2
The systems scenario was an excellent learning experience	40	45	12	2	1
I enjoy the challenges of this course	25	49	17	7	2
My ability to work in a team has improved as a result of this course	49	37	12	2	1
Overall I was happy with the learning outcomes of this course	15	58	19	5	3
I support the aims and objectives of this course as it is now structured	9	46	29	11	4
	27	**48**	**18**	**5.3**	**2.4**

569 students were surveyed >95% responded, their answers are represented as percentages showing that ‘Systems thinking’ and the ‘application-led’ approach had been accepted by students. Final year ‘systems week’ project submissions and examination results for over 90% of students demonstrated proven capabilities in managing design as well as managing complex projects. Students were experienced in team work and communications, with some demonstrating extraordinary leadership skills. Students had a ‘hands-on’ appreciation of working with ethics, sustainability, health and safety, and cultural diversity aspects in the business and project environment.

They had emerged with significantly advanced professional qualifications and there is substantial anecdotal evidence of their success in winning top entry level jobs against fierce competition. During interviews with future employers students found that their technical competence was taken for granted and, instead, the interview concentrated on their practical systems scenario experience and their leadership skills. In addition, anecdotal feedback from alumni suggest that ‘systems thinking’ capabilities are providing valuable benefits in the workplace and that graduates are now influencing more experienced colleagues who are themselves becoming committed advocates of the ‘systems’ approach. The systems approach has also shown that undergraduates are fully capable of mastering complex problems previously considered the preserve of more senior professionals.

To gain direct feedback from alumni, UoA’s Dean of Engineering and senior staff have been interacting with alumni from a variety of companies. Nineteen interviews were conducted, in parallel with process focus group interviews conducted by an independent educational consultant familiar with engineering. Synthesis of the feedback from both sets of data, and given in an internal report, shows the major points of note with respect to systems thinking were – a significant number of graduates were already in management leadership roles recognising that their engineering education had provided them with a strong background in dealing with complex problems including non-technical areas, and that the systems engineering content and projects, underappreciated during their studies, was felt to be an excellent introduction to the real world of engineering. This included their confidence at working in teams, and having to consider social/ economic impacts of engineering.

University

The faculty’s ability to teach advanced professional skills across all engineering disciplines using systems thinking as a framework and methodology is bringing the university in line with industrial best practice and future trends in education. The new advanced capability of engineering graduates improves the profile of the engineering faculty and enhances the reputation of the university. The faculty was able to promote systems thinking in its 2015 submission to IPENZ for accreditation, providing compliance with the latest version of the Washington Accord. Verbal feedback shows satisfaction with what they have seen.

Industry and employers

Independent anecdotal feedback from industry and employers has welcomed the enhanced capability of graduates, and values ‘systems thinking’ as part of the curriculum. Quote: “Just the kind of course I would like to have been on” - Mathew Thompson President of the Auckland University Engineering Association. A number of students’ final reports have been shown to external professional engineers who have been impressed by the quality of the content and its professional presentation. Anecdotally, each of them admits their own teams would be hard pressed to produce an equivalent report in the time available.

Managing change to introduce systems thinking and other aspects of the policy was considered to be particularly challenging. Yet, paradoxically, delivering change was also regarded as the key to achieving the desired teaching outcomes and long term success as an exemplar. A ‘step change’ programme delivering new content across all four years simultaneously was adopted rather than a year on year evolutionary approach, described by Robinson, et al (2012). Although considered “high risk” at the outset this change process was successfully completed with a full roll out of the fully developed course material in 2014.

Enhanced capabilities

An aspect which stands out is the high quality of most scenario reports which are a ‘joy’ to read, and affirm that new knowledge and skills have been gained. The excellent quality of reports, show students have been inspired to go well beyond the normal level of effort in order to succeed and excel. These qualities are also apparent in the high standard of the 3 minute presentations given by a member from each group in the final year ‘systems week’. It is clear that some students have a distinguished career ahead.

Enablers

Discussions in 2010 with enlightened senior members of the engineering faculty enabled the initial scenario to be run in 2011 and the scene to be set for rolling out the full programme.

The change programme, course content, and systems scenarios were designed, and in the most part, delivered by committed ‘practitioners’ with many years’ industrial experience in senior management roles, Robinson et al (2012).

This is seen as the key enabler in providing the programme’s depth, quality, and eventual success; concurred by Morgan R (2014) in one of his main recommendations: “to ensure that industrially experienced engineers are used to provide contextualised learning”.

Barriers

Difficulties were experienced at the faculty level with competing priorities for budget, timetabling, and resources. The faculty’s dominant drive for a traditional ‘research led’ approach presented very significant institutional and cultural barriers to the application-led approach. To this day not everyone on the teaching staff recognises the importance of providing an up to date, best practice, professional development education as essential core element of an engineering degree. Paradoxically, everyone in industry does! Graham (2012) indicates successful change programmes are much more likely to succeed if faculties employ industry experience.The experience at UoA contrasted with that at UCL where the head of department was a champion for change, and provided a level of authority to ensure the programme was implemented and set on a path for success.

Conclusions Implications Recommendations Implications

The experience at UoA shows that the ‘systems thinking’ application led approach to professional development is effective and ‘works’. The outcome of the programme is a proven package of measures which are aligned with the Washington Accord, and form a template or exemplar which could be adopted by any university wishing to raise the quality and capabilities of their engineering graduates.

The programme now enables students to master entirely new professional capabilities and to enjoy exciting new horizons with their longer term careers. Students completing the programme have gained superior knowledge and skills in the professional aspects of engineering. This has given them a broader professional outlook and advanced capabilities enabling them to obtain quality employment and maintain a lead over contemporaries with only a traditional education. In addition, these graduates have transferable skills allowing them to work in any organisation, and to have the potential to be on the ‘top table’. In time it is hoped that graduates of the systems thinking course would bring a much needed, practical approach to problem solving and decisions at these senior levels with consequential benefits to industry and the community at large.

The UoA experience shows that complex change can be delivered successfully as a “step change” across a faculty even within a challenging, large scale environment.

Given the success of this worked example and the benefits it delivers it is hoped that this paper provides some encouragement and some practical help for those ‘champions for change’ who are on a similar journey. The overall ‘systems thinking’ package has now reached a stage where it can be used as a template for change.

The success of the ‘application led’ approach and its attendant teaching policies has been demonstrated as has the means of delivering the changes required. There are, however, some important lessons to take on board to ensure broader success. The dominant barrier is that of government policy which is firmly focused on the ‘research led’ agenda with universities worldwide incentivised on this single criteria. Based on over thirty years’ experience as a practitioner and ten years working at Universities, the author believes that this bias is deeply flawed and disadvantages the engineering professions. It is the author’s opinion that Industry, Trade Associations, and Professional bodies need to be leading the charge to change and lobbying governments for a better balance between a research led and application led approach.

It is hoped that his paper and the successful change which it represents can provide some ammunition in the campaigns which follow.

“But engineering is far more than just about knowledge: an engineer’s core business is to turn theory into practice. As with medicine, engineering expertise only comes with practice, by means of exposure to real-world dilemmas and techniques for addressing them. It is practice that enables an engineer to learn another crucial core skill - to think strategically about the whole picture while keeping an eye on the detail. This whole systems thinking is what allows an engineer to juggle the competing demands of a project, managing risks, controlling costs and keeping to time.”

Engineering the future, why engineering matters http://www.engineeringthefuture.co.uk/matters/

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Acknowledgements

The author gratefully acknowledges the hard work and commitment of the systems team and other members of staff who actively supported the Systems Thinking programme Professor David Ryan Deputy Dean 2010

Dr Robert Kirkpatrick
Mr Colin Nicholas
Dr Keith Adams
Dr Heide
Friedrich Mr
Gary Miller
Dr Mehdi Shahbazpour * for developing an outstanding software system for peer assessment
Dr Reiner Seidel
Dr Martin
McCarthy Mr Jim
Hefkey
Mr Ian Wright
Dr Bridget
Rule Mr
Hugh Morris
Associate Professor Gerard Rowe
Professor Bruce Melville

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