Development of a Multidisciplinary Engineering Foundation Spiral

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Abstract

To operate effectively in today's workforce engineers need to have a muti-disciplinary perspective along with substantial disciplinary depth. This broad perspective cannot be achieved by merely taking 2 or 3 engineering courses outside of the major, but rather will require a radical change in the way we educate engineers. The faculty of the School of Engineering and Applied Science at the University of New Haven have developed a new approach: the *Multidisciplinary Engineering Foundation Spiral.* This curricular model provides the needed mix of breadth and depth, along with the desired professional skills, by providing carefully crafted, well-coordinated curricular experiences in the first two years.

The *Multidisciplinary Engineering Foundation Spiral* is a four semester sequence of engineering courses, matched closely with the development of students' mathematical sophistication and analytical capabilities and integrated with coursework in the sciences. Students develop a conceptual understanding of engineering basics in a series of courses which stress practical applications of these principles. Topics in these courses include electrical circuits, fluid mechanics, heat transfer, material balances, properties of materials, structural mechanics and thermodynamics. Unlike the traditional approach, however, each of the foundation courses includes a mix of these topics, presented in a variety of disciplinary contexts. A solid background is developed by touching key concepts at several points along the spiral in different courses, adding depth and sophistication at each pass. Each foundation course also stresses the development of several essential skills, such as problem-solving, oral and written communication, the design process, teamwork, project management, computer analysis methods, laboratory investigation, data analysis and model development. Students go on to build substantial depth in some of the foundation areas, while other topics may not be further developed, depending on their chosen discipline. Thus the foundation courses serve both as the basis for depth in disciplinary study and as part of the broad multidisciplinary background.

This paper will discuss the design and pedagogical philosophy of the *Multidisciplinary Engineering Foundation Spiral* and describe several of the novel courses in the program.

Introduction

At the 2003 Annual Conference of the American Society for Engineering Education Dr. Shirley Ann Jackson, President of Rensselaer Polytechnic Institute, delivered the main plenary speech. Dr. Jackson outlined the themes which must be addressed by the engineering education community to prepare our graduates for today's challenges. Among her comments was the observation that breakthroughs in technology today are driven by the convergence of multiple fields, thus requiring that engineers develop a multidisciplinary perspective. The engineering education community is challenged to increase breadth without sacrificing disciplinary depth. Dr. Jackson asked whether the time has come to seriously consider designating the master's level as the entry point to the engineering profession.

The faculty of the School of Engineering and Applied Science at the University of New Haven believe that we can educate engineers at the bachelor's level who have the needed mix of breadth and depth, along with the set of professional skills, if we carefully craft curricular experiences in the first two years. A spiral approach to the development of engineering foundation principles, matched closely with the development of students' mathematical sophistication and analytical capabilities, provides an efficient process to develop conceptual understanding. These engineering fundamentals will be taught in multidisciplinary courses which provide an industrial perspective through projects and case studies. This combination is expected to increase retention and develop a broad view of engineering and its role in society. Coordination among the engineering courses in the first few semesters will also enable the development of professional skills (project organization, team management, communications, etc.) which will help students to succeed in upper-level courses and in professional practice.

Traditional Engineering Curriculum

The current problems in engineering education can be summed up in terms of two primary concerns: 1) attracting and retaining talented students in our engineering programs and 2) developing graduates who have the knowledge and skills needed to be successful in today's environment. Likewise, the two areas which have received most attention in efforts to solve these problems have been the curriculum (what we teach) and teaching methods (how we teach).

Although there are some exceptions, most engineering programs are similar to the model in Figure 1. In this traditional model students receive a heavy dose of math and science in the first 2 years, largely unconnected to engineering. Some introductory overview of engineering is usually present in the first year, along with a quantitative course in computer programming and possibly an introductory course in the engineering discipline. The sophomore year usually includes fundamental courses from a few specific disciplines (eg., statics or electric circuits). These are taught from the perspective of one discipline and progress from introductory material to somewhat sophisticated treatment of a relatively narrow spectrum of topics.

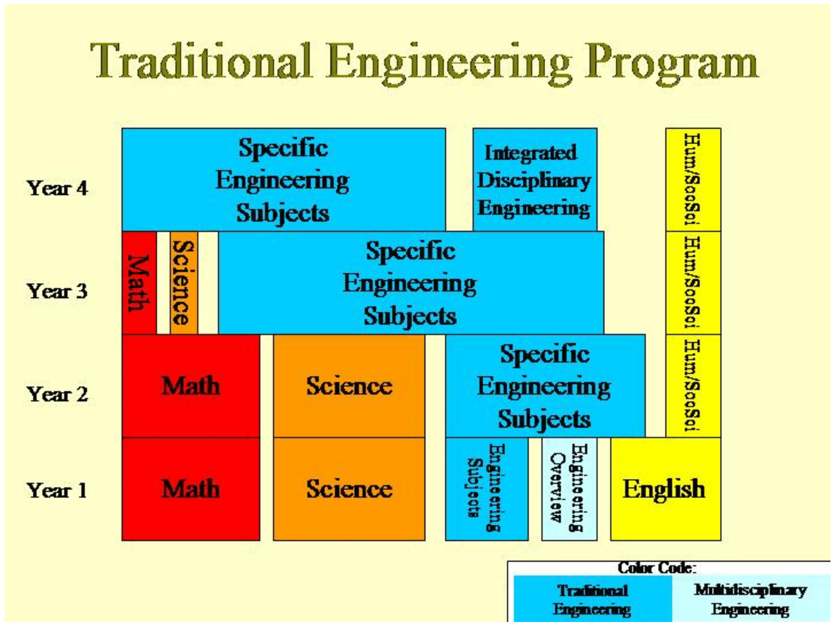

Figure 1

The main content of the traditional engineering program is course work in the chosen discipline. To be sure, these courses will include many topics which are of general interest to engineers in other disciplines as well. However, these are taught from the perspective of the chosen discipline, with little attempt to highlight applications which might be more relevant to others. For example in the thermodynamics course taken by chemical engineering students, the problems are all thermodynamic problems, using methods and equations from thermodynamics and applied to problems of interest to chemical engineers. In the reaction kinetics course, the pattern is similar, with methods and equations focused on the content entitled by the course. With the exception of the first semester overview of engineering, students rarely see a course with a broad perspective, but instead are taught to focus on a narrow set of concepts in each course. Finally, at the senior level, capstone design courses are introduced in which students are asked to synthesize all the methods and knowledge gained in previous courses to solve realistic problems.

Such an approach to engineering education has been successful in the past because it develops graduates with the following attributes:

- Technical Competence
- Detail Orientation
- Focus on Finding the Answer
- Good problem-solving skills

For the world of a generation ago, this was enough to assure success, given the corporate and cultural climate and the tools available for engineering practice. For today, and certainly for tomorrow, this is not adequate. Input from our industrial advisory boards, from the engineering education literature and other sources suggests that several additional attributes are required:

- Ability to appreciate the big picture
- Understanding of non-technical issues
- Team member and team leader skills
- Communication skills
- Systems orientation
- Multidisciplinary view

As used here a multidisciplinary view means an understanding of issues and an ability to apply simple concepts from other disciplines. The design of the traditional curriculum prevents most students from developing many of these attributes. Consider the way discipline-specific courses are generally taught, as outlined in the discussion above. In some cases an instructor may choose to introduce problems of a broader nature, but this is not the norm, since most instructors see their role as primarily developing the students' understanding of the specific content area. It is usually only later that students are asked to synthesize content and methods from several areas in senior level design courses. At that point they are asked to synthesize discrete topics to solve realistic problems. Is it surprising that they perform poorly at this task? They have, in fact, learned well the lessons we have taught them - in content as well as format. We have placed tight boundaries around content areas in the curriculum and they have done the same in their minds. It is our belief that the ability to see the broader picture must be developed first, and then used as a foundation on which to build disciplinary depth.

Previous Work

Considerable work has been done at several engineering schools to address some deficiencies in engineering education. Drexel University, an early pioneer, established the merit of integrating math and science with engineering in its E^4 program[1]. Notable progress has been made by the NSF Engineering Coalitions[2] in introducing active/cooperative learning methods, hands-on and project-based learning, teamwork, industrial design projects, course integration and other innovations. Most of the sustained efforts have been at the freshman level, where there are generally no courses in a specific engineering discipline and therefore less resistance to change. The Foundation Coalition has developed a model to transform the sophomore year into a more multidisciplinary experience. However, this model has not been adopted by many programs and is generally run as a parallel track with traditional programs where it has been adopted. This is the current situation, for example, at Texas A&M and Rose Hulman Institute of Technology, two of the more progressive engineering schools. Thus the sophomore and junior years typically are not changed significantly from the traditional model. Attempts to develop a multidisciplinary perspective by using mixed teams in senior design projects is too little, too late to truly develop the broader view. By this time the students have already adopted the strong disciplinary perspective modeled by faculty mentors.

Another approach taken by a few schools has been to eliminate traditional discipline-specific programs in favor of a broad-based general engineering program. Harvey Mudd College has used this model very successfully, allowing students to concentrate in an area, such as electrical engineering, but not with the depth developed by students taking a major in a specific discipline. While this approach has some merit, our industrial advisors strongly support degree programs in specific engineering disciplines.

Proposed Solution

Faculty of the School of Engineering and Applied Science (SEAS) at the University of New Haven (UNH) recognized the need for a change in our programs to address the deficiencies discussed above, but were unwilling to abandon the individual disciplines. This approach was reinforced by our industrial advisory boards who indicated a strong desire to hire graduates with education in particular disciplines, but who also possessed the desirable attributes listed above. Our response was to create the curricular structure, shown in Figure 2 which blends these features.

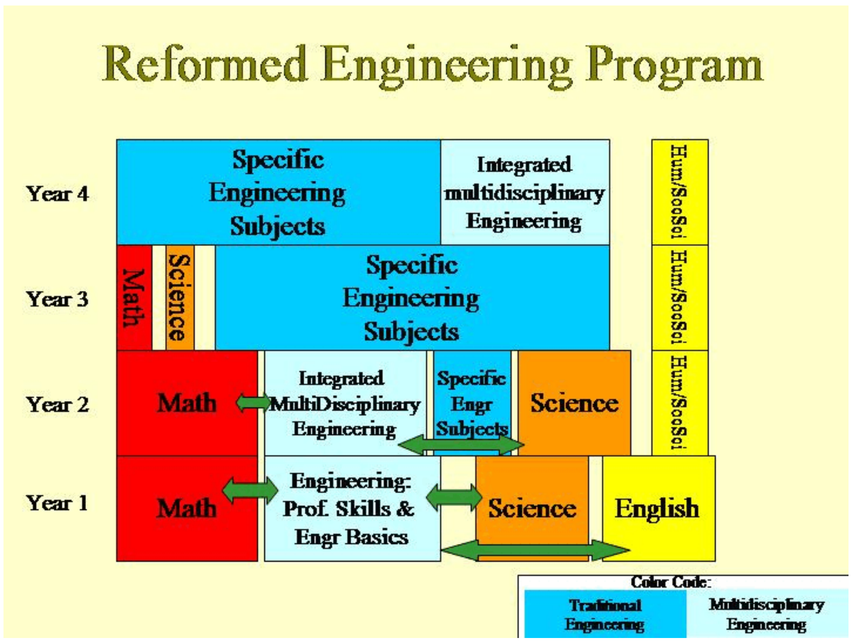

Figure 2

The engineering courses typically found in the first 2 years have mostly been replaced with new courses which are multidisciplinary in form and content and which closely integrate with math and science courses. These engineering foundation courses are indicated here with an EAS designation, for "Engineering and Applied Science". The first year of the program includes four EAS courses, as shown in Table 1.

The second year, shown in Table 2, continues with math and science, includes at least three EAS courses and several discipline-specific choices. Students begin building identity with their discipline in this part of the program by taking on or more discipline-specific courses. In any case they will interact with faculty in their discipline through extracurricular activities sponsored by departments for first and second year students.

Table 1					
Course Requirements - First Year Program					
First Year - Fall			First Year - Spring		
CH115/ 117	General Chemistry I and Lab	4	EAS 120	Chemistry with Applications BioSystems /lab	4
E 105	Composition	3	E 110	Composition & Literature	3
M 117/M115	Calculus I or Precalculus	4	M118/ M117	Calculus II or Calculus I	4
EAS107	Introduction to Engineering	3	EAS112	Methods of Engineering Analysis	3
EAS109	Plan, Design & Experiment	2		Humanity /Social Science Elective	3
		16			17

Table 2					
Course Requirements - Second Year Program					
Second Year - Fall			Second Year - Spring		
M203/*M118*	Calculus III or Calculus II	4	M 204/ M203	Differential Equations or Calc III	3
PH150#	Mechanics, Heat & Waves	4	*PH205#*	Electromagnetics & Optics	4
EAS211#	Intro to Modeling in Engr Systems	3	*ES230#*	Analog Devices in Engr Systems	3
Choose 2 of the following courses:			Choose 2 courses (3 if ES230 not taken)		
EAS210	Materials in Engr Systems	3	EAS222	Fund. of Mechanics & Materials	3
XXyyy	1 Discipline Specific Choice	3	EAS224	Fluid/Thermo Systems	
			EAS232	Project Management & Engr Econ	3
	# indicates integrated courses		XXyyy	1 or 2 Discipline Specific Courses	
		17			16

Multidisciplinary Engineering Foundation Spiral

One very important feature of this curricular model is the treatment of engineering topics during the first 2 years using a spiral curricular approach. The spiral curriculum is a pedagogical construct proposed by Jerome Bruner[3] in which concepts are first introduced in a relatively simple way, then revisited again to provide a deeper understanding, perhaps several times. This approach has been proposed recently for sophomore Chemical Engineering courses[4,5,6] at Worcester Polytechnic Institute and for courses in Electrical Engineering Technology[7] at Purdue University. The courses EAS107, EAS109, EAS112, and EAS211 form a spiral construct of engineering foundation topics (Figure 3) in the first three terms.

In each of these four EAS courses fundamental engineering topics from several different areas are presented at a level matched to the student's current level of development in math, problem-solving, etc. Related topics are revisited in subsequent courses, with increasing analytical sophistication at each step, to reinforce and extend the student's knowledge, skill and familiarity with the foundation topics. By the time students reach the second semester of the sophomore year they have gained a firm grounding in several important engineering foundation areas while developing proficiency in problem-solving, communication, computer solution methods, laboratory skills, team-work and project management.

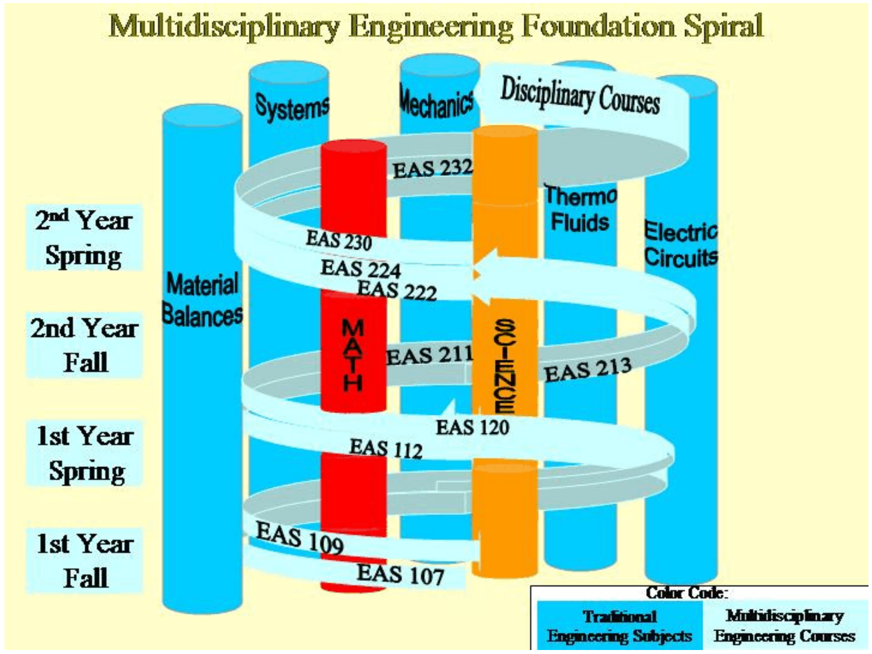

Figure 3

Some content from courses usually seen in discipline-specific engineering courses (sophomore or junior level) is treated in the multidisciplinary EAS courses (freshman and sophomore level). Topics include statics, electric circuits, material balances, thermodynamics and fluid mechanics. Coverage differs by topic and course, varying from basic exposure to simple quantitative models in the early courses. This approach efficiently provides a view of concepts from several areas of study. By contrast, the traditional curriculum requires a separate course for each topical area. Each engineering program will build on the foundation content, developed from a multi-disciplinary perspective, to establish the depth needed by that discipline in key areas of study. Thus the engineering foundation courses provide both breadth and a base for building depth. The features of the 4 foundation courses are shown in Table 3, including the set of "soft" skills developed in each course. The final column in Table 3 lists the team members who developed the course to highlight the breadth of disciplines involved in the development activity.

To illustrate the coordinated spiral of engineering foundation topics, consider the treatment of basic electrical circuits during the first four semesters.

Semester 1: In EAS107 (Introduction to Engineering) students will be introduced to Ohm's law, Kirchoff's current and voltage laws and electrical power in the context of projects with fuel cells and digital devices. Activities will include hands-on measurement of voltage and current, power and efficiency calculations. Concurrently, in EAS 109 (Project Planning and Development), students will encounter these principles while developing experimental projects and working with sensors for computer-aided data acquisition.

Semester 2: In EAS 112 (Methods of Engineering Analysis) students will be given the equations for a problem requiring solution of an electrical network and they will be responsible for developing and programming a solution algorithm. At this point students would not be expected to develop the electrical equations (from Kirchoff's Laws), but will still gain valuable experience manipulating the equations, becoming familiar with common electrical schematic symbols and electrical concepts. A practical application in the form of a case study will help the students remember the electrical principles encountered at this point.

Semester 3: In EAS 211 (Introduction to Modeling of Engineering Systems) electrical topics will be extended to include RC circuits, source transformations and superposition principles. These topics will be a small part of the total content in this course.

Semester 4: In EAS 230 (Fundamentals and Applications of Analog Devices - not shown in Figure 3) students will further develop their knowledge of electrical circuits using applications of interest to a broad set of engineering disciplines. This course is integrated with a physics course which includes electrical phenomena. Electrical engineering students will build additional depth in discipline-specific EE courses.

Table 3
Features of Spiral Engineering Foundation Courses

Course	Features	Skills Targeted	Development Team
EAS 107 Introduction to Engineering (Design)	team project based, engineering and non-engineering students	design process, oral & written communications, engineering disciplines	Nocito-Gobel (Civil) Daniels (Mechanical) Horning (Electrical) Harding (Chemical)
EAS 109 Project Planning & Development	several multi-week engineering projects requiring specific computer tools, planning and experimentation	personal and project management, team member and team leader skills, computer tools, applied to projects	Montazer (Industrial) Daniels (Mechanical) Horning (Electrical) Harding (Chemical) Koutsospyros (Civil)
EAS 112 Methods of Engineering Analysis	problem-driven, use of spreadsheet and programming to develop algorithms to solve engineering problems	algorithm development, use of computer tools, statistics, numerical methods, programming concepts	Collura (Chemical) Ross (Mechanical) Aliane (Electrical) Gibson (Comp Sci)
ES 211 Modeling in Engineering Systems	development of models to solve a variety of engr problems using conservation principles.	problem-solving, simple, but practical applications of industrial relevance	Ross (Mechanical) Collura (Chemical) Nocito-Gobel (Civil) Barratt (Physics)

The treatment of topics from mechanics provides another example of the approach to engineering topic development. In the pilot offering of EAS107P students were assigned the task of designing and constructing a truss bridge and fabricating a scale model for testing. A combination of short class exercises, reading assignments and mini-lectures or discussions were used to introduce basic concepts and terminology, such as loads, reactions, compressive and tensile forces, design safety factors, and failure modes. Modeling was done using a graphical bridge design computer package, which provided calculated forces within the structure along with the maximum load. Students selected design features with consideration of cost as well as safety. Finally students built and tested their designs.

In the pilot of EAS112, students observed a tensile stress test and then analyzed the data to determine the material properties, such as Young's Modulus. They designed a spreadsheet model to analyze stresses in a 7 member truss bridge, including the use of vector algebra and the determination of stress type (tensile or compressive) in each member. In general, equations were developed in class, for example applying force balances, and the students needed to program them into the spreadsheet. The model was developed to allow exploration of the effect of truss height, material of construction and member diameter. Additional homework problems dealing with similar topics will be assigned throughout the course.

In EAS211 students will learn significantly more about the underlying principles, such as dealing with distributed loads and more complex structures. Similarly, a deeper understanding of structural properties of materials will be addressed in EAS213 (Materials in Engineering Systems). Finally in EAS222 (Fundamentals of Mechanics & Materials) students will see completion of the topics typically found in courses in statics and strength of materials. Students in mechanical and civil engineering will go on to study selected areas of mechanics in greater depth in disciplinary courses, while industrial engineering students will not. Most chemical engineering students will end their exposure to the mechanics area with EAS211 and EAS213, however, students with an interest in this area may choose EAS222 as an elective.

A similar topical spiral will be used for fluid mechanics, mass balances, computer programming, thermodynamics and heat transfer. As students move through the curricular spiral, they will compile a "Handbook of Engineering Practice" to organize the principles included in these courses. The handbook will include sections for each topical area (electric circuits, statics, etc.) with a glossary of terms and symbols, a summary of main concepts and a core set of equations. As each topic is encountered in a new course, students will augment the appropriate section of their handbook, thus providing continuity for topics spread across several courses. Table 4 traces the development of analytical skills and conceptual understanding in the foundation courses.

The concept of using a spiral approach to teach engineering foundation concepts has generated much debate among th engineering faculty at SEAS/UNH. Some remain skeptical of this approach, suggesting that students need to focus on a narrower set of related concepts, as would be found in the traditional courses. They are concerned that students will be confused by the breadth of concepts presented in some of the EAS courses. As implementation proceeds, it will be critical that careful assessment be conducted to track student progress in mastery of engineering topics. In addition, a baseline for comparison must be established.

Table 4 Progression of Analytical Skills in Spiral Foundation Courses					
Term / Course	Math Level	Science Course	EAS Context	Concept Development	Quantitative Modeling
1.1 EAS107 EAS109	Calc 1 or Precalc	Chem 1	hands-on projects in teams (107); project management & engineering computer tools (109)	establish conceptual base, explore effect of variables, develop qualitative understanding	use modeling packages in "black box" mode to observe relationships, while exploring design options for projects
1.2 EAS112	Calc 2 or Calc 1	Chemistry with Bio Applica-tions / lab	problem-driven applications in various disciplinary areas using case-studies	manipulate equations, develop familiarity with symbols	equations given to students allowing them to develop algorithms for solution
2.1 EAS211 EAS213	Calc 3 or Calc 2	Physics 1	simple, practical problems of industrial significance	develop quantitative understanding of basics in several engineering foundation areas	develop balance equations, select others as needed for models
2.2 EAS222 EAS224 EAS230	Diff Eqn or Calc 3	Physics 2	focus on smaller sets of topics, typical of those found in pairs of soph or jr level engineering courses	further develop understanding of areas specified by program, in a multidisciplinary format	develop all equations and explore areas in more depth

To achieve the desired objectives, engineering courses in the first 2 years are carefully planned and integrated with each other and with math and science courses. Teams of faculty from several disciplines will oversee each course during both the development and implementation stages to assure that courses stay true to their specific goals as integral parts of the program.

A set of curricular objectives were established that will enable student to more efficiently develop an understanding of important content. These objectives will also provide the set of skills needed for the practice of engineering and have served as guiding principles for the faculty developing the new curriculum. These objectives are outlined below:

- Reduce knowledge compartmentalization
- Maintain consistency and relevance in foundation courses
- Develop an understanding of fundamentals via a spiral curricular approach
- Target engineering content AND specific professional skills in particular courses
- Maintain a learning environment outside the classroom/lab

To achieve the last curricular objective, a First Year Program Coordinator has been appointed to develop and implement a program of activities to supplement classroom instruction. The activities will include speakers from industry, plant tours, tutorial sessions (for math, science and engineering topics), workshops (use of specific computer packages) as well as social functions to augment classroom activity.

Eleven EAS courses (see Table 5) were developed for the engineering programs, four freshman level and seven sophomore level. All were developed by multidisciplinary faculty teams of at least three members, with professionals from industry participating on some teams.

Table 5
Engineering & Applied Science (EAS) Course Summary

Course		Comment	Used by
EAS 107	Introduction to Engineering	engineering disciplines, design process, project-based learning, teamwork skills, presentations, hands-on activities	CM, CE, CN, EE, IE, ME, GE
EAS 109	Project Planning & Development	project course using computer tools for design, simulation, data acquisition, analysis, & presentation; emphasizes planning, management and execution of engineering projects	CM, CE, CN, EE, IE, ME, GE
EAS 112	Methods of Engineering Analysis	development of computer solutions to problems from various branches of engineering, extensive use of spreadsheets and development of programming fundamentals using Visual Basic	CM, CE, CN, EE, IE, ME, GE
EAS 120	Chemistry with Applications in BioSystems	laboratory science course, with general chemistry concepts highlighting applications in modern biological systems	CM, CE electve: IE, ME, GE
EAS 211	Introduction to Modeling of Engr Systems	modeling of simple engineering systems in different fields using the balance principle and empirical laws; includes mass, charge, linear momentum and energy balances	CM, CE, CN, EE, IE, ME, GE
EAS 212	Microcontrollers, Transducers & Data Commun.	introduction to embedded computers, computer organization, interfacing to devices and data communications	development postponed
EAS 213	Materials in Engineering Systems	properties and behavior of solids, liquids and gases of broad interest to engineers, emphasizing selection and use, includes mechanical, chemical electrical and other properties	CM, CE, IE, ME, GE
EAS 222	Fundamentals of Mechanics & Materials	fundamental topics taken from statics, strength of materials & dynamics: force systems, shear & moment diagrams, tension, compression, torsion, buckling, stress/strain transformation	CE, IE, ME, GE
EAS 224	Fluid-Thermal Systems	Study of thermal and fluids principles and applications including thermodynamic laws, basic power cycles, laws of conservation, basic fluid flow and convective heat transfer	CM, CE, IE, ME, GE
EAS 230	Fundamentals & Applications of Analog Devices	fundamentals of analog electrical devices found in engineering, such as sensors, transformers, motors & transmission lines, with some hands-on activity.	CM, CN, EE, IE, ME, GE
EAS 232	Project Management & Engr Economics	introduction to economic analysis and principles useful in project management.	CM, CE, CN, EE, IE, ME, GE
Engineering Programs: CM - Chemical, CE - Civil, CN - Computer, EE - Electrical, IE - Industrial, ME - Mechanical, GE - General. Applied Sciences: CH - Chemistry, CS - Computer Science,			

Faculty from each of the engineering programs considered the new curriculum model during the Spring 2003 and early Fall 2003 semesters to determine which aspects of the model could be adapted for use in their programs. Feedback from program faculty was considered in developing the final versions of the courses and of the curriculum template. Based on the results of this step, 10 of the EAS courses were processed through the university's academic approval system along with curriculum changes in the various programs.

Current Status and Activity

Two pilot offerings of EAS 107 were run during the Fall 2003 semester, one with only engineering students and one with a mixed group of engineering and non-engineering majors. Pilot offerings of EAS 109 and EAS112 are planned for the Spring 2004 semester. A pilot version of EAS211 is slated for the fall of 2004. During the pilot phase, key features will be assessed in comparison to current traditional courses, as summarized in Table 6. An NSF planning grant (Department-Level Reform of Engineering Education) was awarded to the School of Engineering and Applied Science at the University of New Haven to help in this phase of the curricular process[10].

Table 6
Assessment of Engineering Foundation Courses

Course	Control	Features Assessed	Method	Time
EAS107	current format of EAS107	- attitude toward engineering - retention of engineering students - problem-solving skills - specific engineering foundation topics	pre & post tests, student surveys, faculty questionnaire	Fall 2003, Spring 2004
EAS109	entering students in Fall '02, '03	- retention of engineering students - problem-solving skills - teamwork & organizational skills	pre & post tests, student surveys, faculty questionnaire	Spring 2004 Fall 2004
EAS112	Fall 2003 freshmen in CS110	- mastery of computer programming concepts - problem-solving skills - specific engineering foundation topics	pre & post tests, student surveys, faculty questionnaire	Spring 2004
EAS211	Fall 2003 and earlier students	- problem-solving skills - specific engineering foundation topics	pre & post tests, student surveys, faculty questionnaire	Fall 2004

Specific metrics to implement the methods listed in the table were/are being developed. When possible, existing metrics, such as Hestenes Force Concept Inventory[8], will be used. The Foundation Coalition is currently developing such instruments for a number of the engineering foundation areas[9] which are included in our spiral curriculum. Likewise, assessment of student attitudes toward engineering will be taken from existing instruments published in engineering education studies. Faculty questionnaires will be developed to obtain the instructor's perspective on students attitudes, preparation and professional conduct. In several cases it will not be possible to use parallel control groups.

Conclusion

A new curricular model, the *Multidisciplinary Engineering Foundation Spiral*, has been developed and accepted by engineering faculty at the School of Engineering & Applied Science at the University of New Haven. This model is intended to provide a broad engineering background suitable as a foundation for programs in any engineering discipline. In this program engineering topics and professional skills are developed using a carefully coordinated sequence of courses in which concepts and skills are built in a spiral fashion. A somewhat controversial feature of our curriculum is the premise that students can gain a solid grasp of engineering foundation topics in this spiral of multidisciplinary engineering courses. The pilot activity now taking place will allow us to assess the impact of various curriculum features, many of which are applicable at other schools. The success of the multidisciplinary engineering foundation spiral, however, will take longer to assess. A proper judgement can only be made after students have moved into the final years of their engineering programs, and perhaps into engineering practice. We will continue to evaluate and refine the curriculum over the next several years.

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