A Flexible Undergraduate Civil Engineering Curriculum

Wilfrid A. Nixon, Robert Ettema, Forrest M. Holly Jr., and James W. Stoner
Department of Civil and Environmental Engineering
University of Iowa
Iowa City, IA 52242

Abstract

The ABET EC 2000 criteria allow programs to develop flexible approaches to undergraduate education. Such approaches must reflect program objectives and meet all ABET criteria, but content and quantity of the various curricular components (Math and Science, Humanities and Social Science, Engineering Science, and Engineering Design) are defined much less rigidly than previously. Taking advantage of this opportunity, the faculty of the Department of Civil and Environmental Engineering at the University of Iowa has developed a new undergraduate curriculum that permits students exceptional flexibility, consistent with their career goals as well as their possible additional aspirations for learning while at university.

The process began in 1997, when the College of Engineering Faculty redesigned the core curriculum. Math and science classes were modified, the engineering core courses were streamlined, and the College Faculty introduced the notion of "Elective Focus Areas," or EFAs. The concept of EFAs is that students should have between 15 and 21 semester hours (out of 128 s.h. for graduation) to focus on an area of specialization that could be technical or non-technical, as the student wished, provided that this focus was consistent with their career goals. The faculty felt (and this was supported by the College and the various Departmental advisory boards) that facilitating such flexibility was entirely in keeping with the theme "Engineers and something more" which defines undergraduate engineering students at the University of Iowa.

However, this flexibility means that students must meet ABET curricular requirements in only 110 semester hours (the CEE faculty decided to allow students 18 s.h. in their EFAs). The College's new set of core courses had freed up about 5 s.h., but some additional hard choices were necessary. This paper presents the result of this process, and provides preliminary assessment of how the new curriculum is functioning.

Introduction

In February 1997, then Dean Richard K. Miller of the College of Engineering at the University of Iowa created and charged the Curriculum Advancement Task Force (CATF) with development of a vision for a new curriculum to complement the new educational opportunities to be offered by the addition and renovation project. The resulting curriculum vision [1] was voted on and adopted by the faculty after incorporation of comments and suggestions on a draft distributed to a broad constituency, including faculty, staff and student organizations, the College Advisory Board, the College Development Council, university administration, and external consultants in September 1997.

The CATF document put forward two defining characteristics of all engineering programs at The University of Iowa:

- Flexibility in support of individual student aspirations, and
- A commitment to student success

An important motivation implicit in the flexibility characteristic is the thought that engineering students should be able to avail themselves of the breadth of education opportunities that the University of Iowa offers. The College of Engineering recognizes the potential benefits of its location amidst a large, comprehensive university. In particular, the College sees the advantages of linking its own education endeavors to the greater resources offered by the university as a whole. Additionally, the College wishes to stimulate engineering students to gain knowledge in areas beyond engineering. Indeed, the phrase "engineering and more" has become something of a leitmotif for the new curriculum.

In voting to approve the CATF document, the faculty of the College of Engineering adopted the following specific characteristics for all engineering programs (Biomedical, Chemical, Civil, Electrical, Industrial, and Mechanical Engineering):

- Each program is to require 128 semester hours.
- There shall be a set of common core courses that enables students to enroll in engineering with an undeclared major and to change majors without loss of credit through the end of the third semester.
- To ensure education beyond technology, provide flexibility for students to develop thematic options, and complement the technical content of the curriculum, all programs shall have a pool of 36 semester hours of elective courses. The student's portfolio and plan of study guide the selection of appropriate electives. The electives are used to fulfill two College

requirements:

- A general education component of 15 semester hours that ensures focused studies in non-technical areas.
- The remaining 21 semester hours (s.h.) provide flexibility for students to:

  - pursue a formal minor in an approved area, or;
  - earn a certificate in a multidisciplinary area (e.g., Technological Entrepreneurship, Health and Biological Sciences, International Business, Law and Engineering) developed by the College in collaboration with other colleges on campus, or;
  - build strength in a technical focus area, or;
  - pursue a tailored program of study as permitted by the policies of the major program.

It should be noted that in the final curriculum guidelines adopted by the Faculty in June 2001, the above general descriptions of ways to package the 21 s.h. of flexible electives were adopted as recommendations, rather than requirements. Each program was given the freedom and responsibility to develop its own "Elective Focus Area" procedures and specific guidelines, according to their own disciplinary requirements and constraints.

To implement the proposed new vision, an Ad Hoc Core Curriculum Committee (AHC^3) was created in the late Fall of 1998. The AHC^3 completed its work in Spring 1999 and presented a report [2] to the College's Engineering Faculty Council (EFC) for consideration by the faculty. The College of Engineering faculty voted (May, 1999) to:

1. endorse the ideas expressed in the "Core Concepts and Skills" section of the Final Report of the *ad hoc* Core Curriculum Committee;

2. endorse in principle the three-semester common core as described in the Final Report of the *ad hoc* Core Curriculum Committee; and,

3. subject to final faculty approval of detailed course content and semester hour credit, with the initial objective that the new curriculum would be implemented in the Fall Semester, 2000.

Between May 1999 and June 2001, the College Curriculum Committee worked on the details of the proposed new core curriculum, in close consultation with the Departments of Mathematics, Physics and Astronomy, and Chemistry, and prepared a detailed proposal that was adopted by the Engineering faculty in June 2001. Details of course content, delivery, and administrative structure were further elaborated during the summer and fall, culminating in final faculty adoption of the new core curriculum on 19 February 2002.

As the core curriculum approached finalization, programs began finalizing their curricula in Fall 2001 in consultation with their Program Advisory Boards in most cases, culminating in submittal of new UI Catalog descriptions on 8 March 2002. The

entering first-year students in Fall 2002 began their academic careers under the new curricula.

Changes To The Engineering Core

The College of Engineering has various core program requirements that all students must take, regardless of their engineering discipline. In 1997, students in every program took common courses in Math, Physics, and Chemistry. In addition, all students were required to take five engineering core classes: Engineering I (essentially an introduction to engineering and to drafting), Engineering II (a programming class), Statics, Electrical Circuits, and Thermodynamics. Further, each program in the College (of which there are six at the undergraduate level: Biomedical, Chemical, Civil, Electrical, Industrial and Mechanical) was required to offer at least three additional core courses (colloquially referred to as "soft core," to distinguish them from the five "hard core" courses listed above – the choice of terminology is lost in College folk lore), from a listing of about fifteen such courses.

Thus in 1997, each program had a significant number of hours "tied up" in various requirements. Table 1 gives a listing of these common required hours, together with those for the new curriculum. It should be noted that these requirements represent minimum requirements. Obviously, programs such as Chemical Engineering require considerably more than 5 semester hours of chemistry. These minimum hours requirements are set so that students can switch majors up through the end of their third semester (see above). All programs take additional Physics and Chemistry courses (or other science courses) to meet ABET requirements.

Subject Area	Old Curriculum Hours	New Curriculum Hours
Math (and statistics)	16 s.h.	16 s.h.
Physics	8 s.h.	7 s.h.
Chemistry	5 s.h.	4 s.h.
Hard Core Engineering	14 s.h.	14 s.h.
Soft Core Engineering	9 s.h.	Zero
General Education	16 s.h.	15 s.h.

Table 1: Required Core Semester Hours under New and Old Curricula

It can be seen from Table 1 that the new core curriculum did not "free up" huge numbers of hours for the programs. This was problematic since each program had to create enough hours for 21 semester hours of elective focus area (EFA), and so far, the re-arrangement of the core had led to a maximum of 12 semester hours being freed. Even this was misleading, since the "soft core" courses include topics, such as dynamics and mechanics of deformable bodies, that almost have to be included in a Civil Engineering program.

In addition to struggling with semester hours, the AHC[3] developed a set of "core concepts" for the College. The core concepts include:

- design and process-modeling experience

- open-ended problem solving
- teamwork and project management skills
- oral, written, and graphical communication skills
- contemporary computer usage
- multi-disciplinary experience
- ethical, professional, social and global awareness

They are intended to inform and infuse the curriculum from start to finish, and thus create another requirement insofar as implementation of these concepts was seen as requiring all courses to include core concepts, unless there were sound pedagogical reasons not to do so. Nonetheless, the College faculty approved the AHC[3] report and thus programs were required to implement it. A further stimulus to such implementation was the ABET accreditation visit to the College in fall 2002, which presented a firm deadline for implementation of the new curriculum.

As plans for implementation progressed, it became clear that it would not be possible to satisfy all the constraints posed by the faculty, especially for the first three semesters, without a certain degree of flexibility on all parts. Thus, each program was allowed to introduce one required program course into the third semester. All other programs were required to accept this as part of the 21 semester hours of elective focus area for students who transferred between majors at the end of the third semester. It was also decided to introduce General Education Courses (GEC) into the first three semesters, to aid in retention. One further wrinkle was added to the Civil program. This program has had two sub-tracks for some time (general or civil, and environmental). Since environmental students would need more chemistry, their science needs were somewhat different from general civil students, and this had to be accommodated in the final program for the first three semesters. Thus Table 2 shows the final program for the first three semesters for civil engineering students.

Semester 1 (Fall):

	s.h.	Session	Pre(co)requisites: P or C
22M:031 Engineering Math I - Calculus of a Single Variable	4	All	P: H.S. Algebra & Trigonometry
59:005 Engineering Problem Solving I	3	F	
4:011 Principles of Chemistry I	4	All	
10:003 Accelerated Rhetoric	4	F/S	
59:090 First-year Engineering Seminar	0	F	
Total hours	15		

Semester 2 (Spring):

	S. H.	Session	Pre(co)requisites: P or C
22M:032 Engineering Math II - Calculus of Multiple Variables	4	All	P: 22M:031 or AP credit (AB-4)
59:006 Engineering Problem Solving II	3	S	C: 22M:031
29:081 Introductory Physics I	4	F/S	C: 22M:031
22M:033 Engineering Math III - Matrix Algebra	2	All	C: 22M:032

GEC 1 (Civil Eng. sub-track) *or* 4:012 Principles of Chemistry II (Environ. Eng. sub-track	3 4	All All	P: 4:07, 4:011, or 4:17
Total hours	16 or 17		

Semester 3 (Fall):

	S. H.	Session	Pre(co)requisites: P or C
22M:034 Engineering Math IV - Differential Equations	3	F/S	P: 22M:033
29:082 Introductory Physics II (Civil subtrack) *or* GEC 1 (Environmental Eng.sub-track))	4 3	F/S All	P: 29:081; C:22M:032
59:007 Eng. Fund. I - Statics	2	All	P: 22M:031; C: 29:081
59:008 Eng. Fund. II - Electrical Circuits	3	All	C: 22M:034
59:009 Eng. Fund. III - Thermodynamics	3	All	P: 22M:031, 4:011, 29:081
Civil & Environmental Eng. Practice (Dept Selection)	2		P. 59:005, 59:006
Total hours	17 or 16		

Table 2: The First Three Semesters of the New Curriculum

It should be noted that, in addition to the general changes of hours indicated above, substantial refinement of content has also been achieved. All the math, chemistry and physics classes have been redesigned, with full cooperation from their respective departments. Further, the five "hard core" classes have been redesigned to varying degrees. The new Engineering I class (now called Engineering Problem Solving I) breaks students into project teams and has them working on a broad variety of simple engineering design projects during the semester [4] and has been reworked the most of these five classes, but all have had significant changes in them, with twin goals of improving pedagogy (in line with the core concepts described above) and improving retention.

Changes To The Civil Engineering Program

Once the first three semesters had been essentially fixed by the college as a whole, the Civil Engineering program faced the task of developing a curricular program that met ABET requirements (both general and civil) and also allowed students to follow elective focus areas comprising a total of 21 semester hours. The notion of elective focus areas arose from what might be termed a marketing decision. Periodically, the state legislature in Iowa asks why the state has two Colleges of Engineering. The traditional answer has been that the two colleges (at the University of Iowa and Iowa State University) fulfill different roles and offer different educational opportunities. As the College of Engineering at Iowa is the smaller of the two Colleges, it behooves the College to ensure that its educational approach is distinct from that at Iowa State (which as a land grant institution perhaps represents a more traditional educational approach).

The College of Engineering decided to build on a theme of "engineering and something more" for our undergraduates. The "something more" would be expressed in the elective focus areas. We had noted over a number of years (without any formal study of the phenomenon) that many of our best students did double majors or minors, with the non-engineering major or minor often being from liberal arts (e.g. music, a foreign language, theater arts etc.) or in business. The College had also begun a Technological Entrepreneurship Certificate, joint with the Business College, which has proved popular. While it is our expectation that most students will do an EFA in a technical area (related to

if not part of Civil Engineering) we hope that some will consider less obvious areas for their EFAs. There is a risk here, much discussed with our advisory board, that a student taking a non-traditional EFA (in dance, to use a much discussed example) may not be able to follow a career in civil engineering thereafter. The faculty has set in place various checks to ensure that a student cannot embark on a non-traditional EFA without extensive advising that will include specific discussion of future employment prospects and the implications of their EFA choice upon them.

Nonetheless, it is important that the program develop a curriculum (or in fact, two curricula, one for general civil and one for environmental) that satisfies the ABET requirements in terms of semester hours. Specifically, after the first three semesters had been completed, the remaining five needed to cover: 3 s.h. of Math; 5 s.h. of science; 32 s.h. of engineering; and 12 s.h. of GECs, while still leaving room for 21 s.h. of EFAs. Further, the specific requirements of civil engineering programs (four technical areas at a level of competence) had to be covered also. All of this had to be accomplished in 80 semester hours, which makes for some challenges.

Surprisingly, the first challenge proved to be not one of bookkeeping (finding the hours) but of how best to use this opportunity to fully incorporate the core concepts into the curriculum. Faculty is in general enthused about this opportunity, and has stepped forward to develop new classes eagerly.

The following motivations and considerations guide the Program modifications:

1. Provision of a contemporary and attractive overall vision for the Program;
2. Streamlining the course sequence for the Program's four technical areas (environmental, hydraulics & water resources, structures and materials, transportation) offered in a dual sub-track arrangement (Civil and Environmental);
3. Tuning of the curriculum overall to better match the Program's Objectives and Outcomes; and,
4. Assurance that the Program meets ABET's semester hour (s.h.) requirements for science, mathematics, and professional knowledge.

Motivation 1 arises in part from a broad, nation-wide sense that civil engineering must affirm and invigorate its image and its role in society. Additionally it is motivated by the Program's wish to develop a more cohesive and better integrated curriculum, one that better meets the Program's Objectives (see Section B.). Numerous articles, such as [4], stress the role of civil engineering in developing and maintaining society's physical infrastructure (transportation, structures, water supply, environment well being, together with facets of information management, economics, and public policy). That role behooves civil engineers to know more about the overall workings of society's physical infrastructure and how infrastructure is managed. In short, civil engineering education is required to provide a more holistic view of the role of civil engineers in society. Therefore, the Program is modifying its curriculum for the following reasons:

- better acquaint students with the broader role of civil engineering
- provide background in four technical areas central to that broader role

- instill in students the sense of connectivity with other technical disciplines
- found the curriculum on a sturdy basis of science
- emphasize the importance of communication

These considerations are expressed in the Program's Objectives and Outcomes. The Program considers that the four technical areas of environmental, structural, water-resources, transportation are the appropriate areas for the Program's Objectives.

Motivation 2 is consequent to faculty's wish to enhance the balance and flow of technical knowledge through the Program's curriculum. In particular, some equitable re-distribution of (s.h.) time is needed in order to cover the four technical areas.

Motivation 3 is consequent to motivations 1 and 2, and entails slight adjustments within the overall curriculum, including adjustment in the flow of information provided through individual courses. For example, some courses will be adjusted so as to facilitate the Program Outcome of students having an opportunity to be guided by professionals in a design experience.

Motivation 4 follows directly from the need to ensure the Program meets ABET recommendations regarding the nature of curriculum content. The proposed curriculum has been checked to ensure that it conforms to the requisite semester hours (s.h.) of science, mathematics, professional components recommended by ABET.
The modifications align the new curriculum to conform to the following rationale:

1: *A sequence of two, central courses that, early in the curriculum, provide an overview of civil and environmental engineering, and will provide some basic skills need throughout the subsequent courses.* One new course (53:015 Civil and Environmental Engineering Practice) is placed in Semester 3. The second new course (53:168 Civil Infrastructure) will be placed in Semester 4. No such courses presently exist in the Program curriculum.

About one third of the course 53:015 Civil and Environmental Engineering Practice (2 s.h.) will provide an introductory overview of civil and environmental engineering, including its history and traditions, as well as describing the contemporary role of civil engineering. The remaining portions of the course will provide a set of basic technical skills that students will use throughout much of the subsequent curriculum; topic will include engineering drawings, geographical information systems, and elements of surveying. It is likely that this course will be team taught in Semester 3 by several faculty, or by a faculty member assisted by an adjunct faculty member.

The course 53:168 Civil Infrastructure (3 s.h.) will build on the course 53:015 Civil and Environmental Engineering Practice. It will continue the flow of general information concerning the role of civil engineers in managing as well as designing society's civil infrastructure. The course will have a transportation theme, but include content of general use; e.g., engineering economics, legal issues, engineering management, and lifeline

engineering (reliability of civil infrastructure).

2: *Two new science courses to provide information underpinning important aspects of subsequent courses, and strengthening the science component of the curriculum.* One course is 53:150 Natural Environmental Systems (3 s.h.), which will be offered in Semester 4. The other course is 53:114 Geoscience for Engineers (3 s.h.), also to be offered in Semester 4.

The course 53:150 Natural Environmental Systems will strengthen student's science-background preparation for the subsequent sequence of courses in for the technical area of environmental engineering. The course covers the natural chemical and biological processes at play in nature, about which civil engineers need to be knowledgeable. Information from this course will underpin aspects of the engineering course 53:155 Environmental Engineering: Engineered Systems (described below), as well as other courses. In the existing curriculum, this is a 4 s.h. course, and includes some engineering content. In the new curriculum, 53:150 is shortened to 3 s.h. and will be a science course.

The course 53:114 Geoscience for Engineers will instruct students in the natural physical processes and conditions of relevance to subsequent engineering design activities (i.e., the hydrologic cycle, watershed processes, landform morphology, tectonics, volcanism, and aspects of rock formation and types). The present curriculum lacks such content. Information from this course will underpin aspects of several engineering courses; notably the existing course 53:030 Soil Mechanics, the new course 53:071 Principles of Hydraulics and Hydrology, and the existing elective course 53:139 Foundations of Structures, as well as other courses in both the Program's civil and environmental sub-tracks. Together with the course 53:030 Soil Mechanics, the new course will strengthen the Program's instruction in the geomechanics technical area.

3: *Engineering courses in the Program's designated four technical areas will lead with a "principles" course, then be followed by a "technical-design" course*. The "principles" courses start in Semester 5 and continue through Semester 6. The courses will be 53:033 Principles of Structural Engineering (3 s.h.), 53:155 Principles of Environmental Engineering (3 s.h.), 53:063 Principles of Transportation Engineering (3 s.h.), and 53:071 Principles of Hydraulic and Hydrologic Engineering (3 s.h.). The new course 53:071 Principles of Hydraulic and Hydrologic Engineering (3 s.h.) is a merging of the present two courses 53:071 Principles of Hydraulics (2 s.h.) and 53:078 Principles of Hydrology (2 s.h.). The new course reduces, by 1 s.h., student activity in the Programs HWR technical area. This trimming was deemed necessary in order to provide a more equal balance of time for the Program's four technical areas.

4: *The "principles" courses lead to two "technical-area design" courses that students will take in Semester 7*. Students will be required to choose two of three design courses. Each design course has a primary theme (e.g., water-resources engineering design), and may include a secondary theme (e.g., foundation design). The design

courses will link two or more of the technical areas.

5: *A capstone design course that makes the connection between the broader responsibilities of civil engineering (i.e. infrastructure development/management, economics, social issues, etc.) and the four technical areas.* The present capstone course meets this purpose quite well, though opportunities to strengthen the course will be pursued.

Tables 3, 4, and 5 show the curriculum for the Sophomore, Junior, and Senior years respectively of the program. Table 3 includes one semester of overlap with Table 2 (which included the third semester). As might be expected, there is a progression through the curriculum from the principles and underlying basics, which are the heavy focus in the sophomore and junior year, through to design and applications (for those who have chosen more technically focused EFAs) in the junior and senior years.

Semester 3 (Fall)

	Credit	Pre(co)requisites: P or C
22M:034 Engineering Math IV	3 s.h.	P: 22M:034
029:018 Physics II or GEC1 (for Environmental Sub-track) 3 s.h.	4 s.h.	P: 029:081, C: 22M:032
059:007 Engineering Fundamentals I – Statics	2 s.h.	P: 22M:031; C: 029:081
059:008 Engineering Fundamentals II – Electrical Circuits	3 s.h.	C: 22M:034
59:009 Engineering Fundamentals III – Thermodynamics	3 s.h.	P: 22M:031, 4:011, 029:081
53:015 Civil & Environ. Engineering Practice	2 s.h.	P: 059:005, 059:006
TOTAL HOURS SEMESTER 3	**17 s.h.**	

Semester 4 (Spring)

22S:039 Probability and Statistics for Civil Engineers	3 s.h.	P: 22M:032
057:010 Dynamics	3 s.h.	P: 22M:034 and 059:007
053:150 Natural Environmental Systems	3 s.h.	P: 4:011
057:019 Deformable Bodies	3 s.h.	P: 059:009, C: 22M:034
053:114 Geoscience For Engineers	3 s.h.	
GEC 2	3 s.h.	As in Hum/SS currently – from a structured template
053:020 CEE Sophomore Seminar	0 s.h.	
TOTAL HOURS SEMESTER 4	**18 s.h.**	

Table 3: Curriculum in Sophomore Year

Semester 5 (Fall)

053:030 Soil Mechanics	3 s. h.	P: 057:019
053:033 Principles of Structural Engineering	3 s.h.	P: 057:019
057:020 Fluid Mechanics	4 s.h.	P: 22M:034, 057:010, 59:009
053:063 Principles of Transportation Engineering	3 s.h.	P: 22S:039
053:086 Civil Construction Materials	3 s.h.	P: 59:007, 057:019, C: 053:033
053:091 CEE Professional Seminar	0 s.h.	
TOTAL HOURS SEMESTER 5	**16 s.h.**	

Semester 6 (Spring)

053:155 Principles of Environmental Engineering	4 s.h.	P: 053:150
053:071 Principles of Hydraulic & Hydrologic Engineering	3 s.h.	P: 057:020
053:168 Civil Infrastructure	3 s.h.	P: 053:063, C: 053:155
EFA 1	3 s.h.	From EFA determined with advisor
EFA 2	3 s.h.	From EFA determined with advisor
053:091 Professional Seminar	0 s.h.	
TOTAL HOURS SEMESTER 6	**16 s.h.**	

Table 4: Curriculum in Junior Year

Semester 7 (Fall)

CEE Design Option A	3 s.h.	Chosen from three CEE design courses
CEE Design Option B	3 s.h.	Chosen from three CEE design courses
GEC 3	3 s.h.	As in Hum/SS currently – from a structured template
EFA 3	3 s.h.	From EFA determined with advisor
EFA 4	3 s.h.	From EFA determined with advisor
053:091 CEE Professional Seminar	0 s.h.	
TOTAL HOURS SEMESTER 7	**15 s.h.**	

Semester 8 (Spring)

053:084	3 s.h.	Capstone Design
GEC 4	3 s.h.	As in SS/Hum currently – from template
GEC 5	3 s.h.	As in SS/Hum currently – from template
EFA 5	3 s.h.	From EFA determined with advisor
EFA 6	3 s.h.	From EFA determined with advisor
053:091 CEE Professional Seminar	0 s.h.	
TOTAL HOURS SEMESTER 8	**15 s.h.**	

Table 5: Curriculum in Senior Year

In its final form, the curriculum did not accommodate 21 semester hours for EFAs. Accordingly, three of the 15 GEC hours must be chosen so that they complement the EFA selection of each student. This is obviously a compromise, but given the constraints, one that does not seem to sacrifice too much of the original intent of the curriculum revision.

Table 6 summarizes the various categories of hours in the revised curriculum as it now

stands.

Category	Semester Hours
Mathematics	16 s.h.
Basic Science	18 s.h. (includes Natural Systems, Geoscience)
Communication	4 s.h. (Rhetoric)
Engineering General Education Requirement	15 s.h.(1 GEC as EFA course)
Engineering Core	24 s.h. (EPS 1 and 2; EF 1, 2, 3; Dynamics, Def. Bods, Fluids)
CEE Program Courses	33 s.h.
Elective Focus Area	18 s.h. (21 s.h. including 1 GEC in EFA area)
TOTAL HOURS	**128 semester hours**

Table 6: Categorization of Semester Hours by Type in New Curriculum

Elective Focus Areas

The new curriculum provides 21 s.h. for courses associated with elective focus areas (EFAs) that students may choose to pursue. Focus areas can be quite diverse, but must be reasonably coherent (as explained above for the College). To a large extent, students are free to select focus areas unrelated to engineering, and could be in the humanities or arts; e.g., music, language, history. The Program (and the College) requires that non-technical EFAs be undertaken as a Minor.

Though some students may have well-defined focus areas, Program faculty envision the likelihood that most students will need direction as to possible focus areas. Additionally, faculty see the elective focus areas as an opportunity to work with other UI departments in offering elective focus areas that form stimulating and useful extensions to the Civil Engineering Program. The following extensions are developed or being developed:

1. Extensions enabling students to gain deeper technical knowledge in the Program's four technical areas (structural, transportation, environmental, hydraulic/water-resource).

2. Extensions enabling students to gain knowledge in engineering areas related to the four technical areas, such as engineering mechanics, optimization methods, or environmental flows.

3. Extensions as sets of courses that could enhance the overall breadth of engineering education available through the Program; possible EFA course sets include urban and regional planning, technical entrepreneurship (a certificate is available), geology, economics; transportation (human aspects); global studies; and various aspects of

geography.

The Program presently has developed EFA opportunities collaboratively with other engineering programs (e.g., Mechanical Engineering) and with UI's Department of Urban and Regional Planning, and Department of Geosciences. The Program is investigating further EFA opportunities.

While the EFAs are still being developed at present (and, if they work as planned, will never be entirely static, since they are intended to respond to student interests) a typical Civil Engineering oriented EFA in the area of structures would likely include the following components.

An EFA in structures primarily entails additional courses in analysis and design. They would include Finite Element Analysis, Pre-Stressed Concrete Design, Optimal Design Methods, and Timber and Masonry Design as required courses. Students would then choose two courses from a pool of four or five including such courses as Foundations Engineering, Structural Vibrations, and Fracture Mechanics (the pool of courses at present includes six or seven similar courses). Finally, the seventh course in the EFA would also have to satisfy one course in the student's GEC requirement. Depending on their choices, this might be a course from the History department on architecture in history, or it could be a geography course that discusses land usage. The nature of EFAs is such that final decisions will depend on the student and their advisor. This flexibility is an inherent part of the EFA process.

Preliminary Assessment

Since the new curriculum only began in Fall semester 2002, any assessment is at present very preliminary. Students are definitely enthusiastic, but the degree to which this enthusiasm continues is as yet unknown. Changes in semester 1 (primarily in the Math classes and Engineering Problem Solving I) have been very well received, and certainly suggest that the goals of improved pedagogy and retention are being met initially. Clearly more time must elapse before a complete judgment can be made.

It should be noted that no attempt has been made in this paper to compare the new CEE curriculum at Iowa with those at other institutions around the United States. Obviously, the College curriculum changes drew upon experience at other institutions, as did some of the developments in the new CEE curriculum. Many other programs allow many hours of electives, but in most cases with which we are familiar, those electives are technically oriented. The freedom to take non-technical electives differentiates the Iowa program.

Conclusions

The Civil Engineering undergraduate program at the University of Iowa has developed a new undergraduate curriculum that permits students exceptional flexibility, consistent with their career goals as well as their possible additional aspirations for learning while at university. The curriculum was implemented in Fall 2002. While it is too early to say definitively whether the new curriculum is of value, early indications are positive.

Bibliography

1. Curriculum Advancement Task Force, 1997. "Educating the Individual: Engineering Education at The University of Iowa."

2. Ad Hoc Core Curriculum Committee, 1999. Final Report.

3. Hornbuckle, K., and Valentine, R., 2003. "Engineering Problem Solving I," in preparation.

4. ASCE, 2001. Civil Engineering Practice in the Twenty-First Century. ASCE Publications, Reston, VA

Biographical Details

WILFRID NIXON
Wilfrid Nixon is a Professor of Civil and Environmental Engineering at the University of Iowa and a research engineer at IIHR - Hydroscience and Engineering. He is also Director of the University of Iowa Center for Teaching. Dr. Nixon, a Professional Engineer in the State of Iowa, received a B. A. in Engineering from Cambridge University, England in 1981, and a Ph. D. in Engineering from Cambridge University in 1985.

ROBERT ETTEMA
Robert Ettema is a professor, and department chair, of Civil and Environmental Engineering at the University of Iowa. He also is a research engineer with IIHR - Hydroscience and Engineering. Dr Ettema, a professional engineer in the State of Iowa, attained the B. Eng. degree at the University of Auckland, New Zealand in 1975, and the Ph. D. degree at the University of Auckland in 1980.

FORREST M. HOLLY JR.
Forrest Holly is Professor of Civil and Environmental Engineering at the University of Iowa, and a Research Engineer at IIHR - Hydroscience and Engineering. He has served as Chair of Civil and Environmental Engineering, and is currently serving as Associate Dean of Engineering for Academic Programs. Dr. Holly is President of the International Association of Hydraulic Engineering and Research (IAHR), and is a licensed professional engineer in Iowa, Illinois, and Colorado. Dr. Holly received a BS from Stanford University in 1968, an MS from the University of Washington in 1969, and a PhD from Colorado State University in 1975, all in Civil Engineering - Hydraulics.

JAMES STONER
James Stoner is an associate professor of Civil and Environmental Engineering and Urban and Regional Planning at the University of Iowa. He has previously served as Associate Director of the Center for Computer Aided Design and Director of the Iowa Driving Simulation Laboratory. Dr. Stoner received his Ph.D. in Civil Engineering from Northwestern University.