AC 2008-2220: PROCESS AND CHALLENGES OF BUILDING A NEW CIVIL ENGINEERING CURRICULUM AT A REGIONAL CAMPUS

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Process and Challenges of Building a New Civil Engineering Curriculum at a Regional Campus

Abstract

Indiana University-Purdue University Fort Wayne (IPFW) is a regional campus of Indiana University and Purdue University and administratively managed by Purdue University. IPFW is the largest public university in northeastern Indiana, serving more than 12,000 students. The civil engineering program is the most recent addition to the Department of Engineering, which offers B.S. degrees in civil, computer, electrical, and mechanical engineering.

The paper presents the process and challenges of establishing a new Civil Engineering curriculum and layout the techniques used in addressing these challenges. The paper addresses three issues: developing a curriculum that meets the regional needs; the Purdue University requirements, and 2007 ABET criteria. The challenge is to achieve these goals under several constraints including limited resources; accepting students to new program with different background such as transfer students from other institutions and students for technology programs, and the process of offering new core courses for advanced students in the program.

The curriculum was based on evaluating all CE programs in the state of Indiana and close by programs from neighboring Michigan and Ohio states. The paper will present the methodology used in comparing all programs curricula and the process of selecting the curriculum of the new program.

Introduction

Indiana University-Purdue University Fort Wayne (IPFW) is a regional campus of Indiana University and Purdue University and is the largest public university in northeastern Indiana, serving more than 12,000 students. The civil engineering program is the most recent addition to the Department of Engineering, which offers B.S. degrees in civil, computer, electrical, and mechanical engineering.

The campus is a commuter campus and most of the students are working either full time or part time. A recent survey of freshmen students at the Engineering College found that about 86% of the students were full time students and about 14% were part time students. Most of the students (70%) were employed as follows: 16% working full time, 30% working part time with 20 or more hours per week, and 18% were working part time with less than 20 hours per week[1].

The development the Civil Engineering program at IPFW University followed a typical procedure of creating a new program at any US higher education institution. The procedure includes preparing and submitting a proposal for approval by the university administration and then state agencies, several revisions of the proposal were conducted to comply with comments and recommendations at each level of the approval chain; securing the final approval of the program, and implementation. The key component of the process is to develop the curriculum to the program while achieving harmony the civil engineering programs within the department.[2, 3]

The implementation component usually include integrating the new program in the university system such as entering the new courses with their description in the Banner System and in University Bulletin; recruiting new faculty and students for the program, developing laboratory facilities which involve securing space and equipment, develop and start implementing an assessment plan in preparation for the Accreditation Board for Engineering and Technology (ABET) accreditation, and start offering courses[4].

Objective of the study

The objective of the study is to modify the proposed curriculum of the new Civil Engineering (CE) program developed by mechanical engineering faculty at the Engineering department. The goal of the proposed modification is to make the program comparable to curricula offered at CE programs in the US in general and the State of Indiana and nearby schools in Michigan and Ohio in particular. Moreover, the program should serve the needs of Indiana as presented in the survey of 27 civil engineering firms in the State. The proposed modification would fortify the program with the same resources listed in the original proposal.

Methodology

The civil engineering program proposed curriculum was compared to 12 other Civil Engineering programs. Half of these programs are from schools in the State of Indiana that offer similar CE program and the other half from nearby schools in Michigan and Ohio. The modifications to the current curriculum are proposed based on the comparison with other schools; results of a survey of 27 local companies presented in the original proposal; and 2007 ABET criteria.

The following are the list of the Civil Engineering Programs used in the comparison:

Indiana:

1) University of Notre Dame, 129 credit hours.
2) Valparaiso University, 132 credit hours.
3) Purdue University, West Lafayette, 133 credit hours.
4) Tri-State University, 132 credit hours.
5) University of Evansville, 128-135 credit hours.
6) Rose Hulman Technical Institute, 194 term credit hours (129 semester credit hours).

Michigan

7) Western Michigan University, (127+University requirements) credit hours.
8) University of Michigan, Ann Arbor, 128 credit hours.
9) Michigan State University, 128 credit hours.

Ohio

10) University of Cincinnati, 192-197 term credit hours (128-131 semester credit hours).
11) University of Toledo, 128 credit hours.
12) Ohio State University, 200 term credit hours (133 semester credit hours).

In summary, the number of credit hours to earn a B.S. degree in Civil Engineering ranges from 128 to 133 credit hours. The Department of Engineering at IPFW has currently four programs with total credit hours ranges from 126-128 hours[5]. Therefore, it has been decided to set the requirement for the new civil engineering program to128 credit hours to meet the state minimum, be similar to neighboring universities, and to meet the maximum possible hours set by the Engineering Department at IPFW.

The author was the first civil engineering faculty hired by the department. The first task for him was to evaluate the current curriculum presented as presented in the program proposal. In order to evaluate the current proposed curriculum, a comprehensive comparison between IPFW civil engineering curriculum and other universities was conducted. The goal of this comparison was to check on the current courses offered in the original proposed curriculum and compared it to other schools. A summary of the key findings is presented in Figure 1. As shown in the figure, there are courses in the original proposed curriculum that are not part of degree plan of any other school in the list. For example, a course entitled “Stochastic” was proposed but no other school offer it in their curriculum. In addition, there are other courses such as “Statistics and Probability for Engineers” and “Construction Management” that are offered by many other schools and are not part of the current curriculum.

Part of developing the proposal for the program, a survey was conducted in the state to assess the needs for civil engineers and the demand in each specialty. Table 1 presents the number of engineers currently employed with companies surveyed based on their discipline in the Civil Engineering area. Table 1 shows that 30% of civil engineers employed practice “general” civil work. The hiring in the areas of structural and construction management were 18% followed by

14% in the areas of transportation and environmental engineering. Finally, the demand for geotechnical engineers was about 7%.

# of Schools Offering the Course	Course	Title	School (1)											
			Indiana						Michigan			Ohio		
			1	2	3	4	5	6	7	8	9	10	11	12
3	MA 351	Elementary Linear Algebra	3.5		3								3	
2	ME 293	Measurements and Instrumentation						4	2					
10	ME 318	Fluid Mechanics	3	4		3		4	3	4	4	3	3	4
2	ME 303	Material Science and Engineering			6		3							
0	CE 303	Route and Construction Surveying												
3	ENGR 411	Capstone Design Project II					4	4				3		
0	CE 392	Stochastics												
11		Statistics & Probability (2)	3	3	3	3		4	3	5	3	3	3	5
9		Civil Engineering Materials (2)	4	3				4	3	4	4	5	3	4
8		Construction Management (2)		3	3		3	2	4	3		6		1
4		Computaional Methods	3							4	3	3		
7		Steel Design	4	3		3	3	3					3	4
Total Hours Required for Graduation			129	132	133	132	128+	129	127+	128	128	128	128	133

(1) List of Schools

Indiana
1) University of Notre Dame
2) Valparaiso University Valparaiso
3) Purdue University
4) Tri-State University
5) University of Evansville
6) Rose Hulman Technical Institute*

Michigan
7) Western Michigan University
8) University of Michigan
9) Michigan State University

Ohio
10) University of Cincinnati*
11) University of Toledo
12) Ohio State University*

(2) These courses are listed under this name or similar names in other schools

1) Statistics for Engineers
2) Statistics & Probibility applications for Engineers
3) Statistics & Probibility for Civil Engineers
4) Statistical Applications in Civil Engineering

5) Engineering Materials

6) Project and Construction Management

*: using quarter system. The semester credit hour is assumed to be equal to 2/3 of quarter hour.

Figure 1: Summary of curricula comparison

Table 1: Demand for Civil Engineers by Specialty in the Northeast Indiana

Decipline	Number	%
Civil (general)	17	30%
Structural	10	18%
Construction	10	18%
Transportation	8	14%
Environmental	8	14%
Geotech	4	7%

Recommendations for Curriculum Modifications:

The following are proposed recommendations to the Civil Engineering curriculum:

I) Courses recommended for removal from the curriculum:

1) Route and Construction Surveying (3): this course is not taught at any other institution as a core course. Most programs are offering only one course of surveying. In addition, many institutions are either moving away from surveying or modifying the course to include emerging technologies such as GPS and GIS in a new course called Geomatics. These changes will be adapted to the current surveying course listed in the program. This course, however, will be moved to be an elective course.

2) Stochastic (3): this course does not exist in any other school and it is considered to be an advanced course for CE students. However, there is an urgent need for an introductory course in statistical application in civil engineering. This course will be presented later in this paper.

3) Measurements and Instrumentations (2): very few schools are offering this course as part of their curriculum (i.e., 2 out of 12).

Total credit hours suggested for removal is (8) credit hours.

II) Courses recommended for addition to the curriculum:

1) Fluid Mechanics (3+1): this course is necessary for CE students to understand the concept of fluid mechanics. It is taught by most of other institution (i.e., 10 out of 12) as a core course. The lab in this course will replace the Hydraulics lab (-1) that currently exists in the curriculum.

2) Statistical Applications in Civil Engineering (3): this course covers the applications of statistics and probability in all areas of Civil Engineering. Most of the universities (11 out of 12) have this course or similar courses.

3) Construction Management (3): this course is important for CE students to have knowledge in construction engineering and management. There are eight schools offering this course in their core curriculum as shown in Figure 1. In addition, the industry survey conducted with 27 companies in Indiana showed construction engineers as the second highest hires when compared to other disciplines in Civil Engineering.

4) Soil Mechanics Lab (1): The Soil Mechanics course does not have a corresponding lab. It is recommended to add an hour of lab for the course.

5) Environmental Lab (1). The Environmental Engineering course does not have a corresponding lab. It is recommended to add an hour of lab for the course.

Total credit hours suggested for addition is (11) credit hours.

III) Courses recommended for replacement:

1) Civil Engineering Materials (3+1): most of the schools (i.e., 9 out of 12) in the survey are teaching this course. This course is proposed to replace Material Science and Engineering

(ME303) including the lab (ME304) and Reinforced Concrete Lab courses. This course and the corresponding lab will cover materials related to Civil Engineering.

Total credit hours suggested for addition/removal is (0) credit hours.

IV) Courses recommended for Modification:

1) Capstone Design Project I & II (1+3): in the area of Civil Engineering there are very few schools are offering this course with (6) credit hours as part of their curriculum. As shown in the survey only one school (i.e., University of Evansville) is offering two sequential courses. The other two schools listed in the table, Rose Hulman and Ohio States are using quarter system and they need two terms for the course. The total of 6 quarter hours is equivalent to 4 semester hours. However, one semester provide very short time for students to pick-up a project, full understand what to do, collect the information needed and design the project. It is very important for student to spend some time to digest the concept of this course, select their project, and be totally prepared for the design part. Thus, it is recommended to reduce the credit hours for Project I to only one hour and keep the second part 3 hours.

2) Modifying Course Title:

   a. Change Structural Analysis I to Structural Analysis.

   b. Change Geotechnical Engineering I to Soil Mechanics.

   c. Change Theory of Reinforced Concrete to Design of Concrete Structures

Total credit hours suggested for removal is (2) credit hours.

The bingo sheet for the program for the old program and new modified program are shown in Figures 2 and 3, respectively.

V) Elective Courses Modification:

In order to fortify the student knowledge in civil engineering and give them more depth in one or more of their favorite areas, Figure 4 presents the proposed technical elective courses for civil engineering program. In order to meet new ABET criteria for the fourth area in science, the program offers a flexible way to meet this requirement while giving students a choice of selecting a course in their area of interest. As shown in Figure 4, at least one technical elective course shall be taken from the science group. In order to fortify the students' technical background in the area of civil engineering, a maximum of two elective courses can be taken from non-civil engineering courses.

Figure 2: Original BSCE degree in Civil Engineering

BSCE Degree
Department of Engineering

Proposed Date: Fall 2006
All engineering & technical elective courses must have a combined minimum GPA of 2.0.
Course sequencing follows the academic year, and assumes beginning the program in the Fall Semester.
P = Pre-requisite, C = Co-Requisite or Pre-requisite

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1st Semester 16 credits	**MA 165 (4)** P: MA 154 or MA 159 (C or better), or placement	**CHM 115 (4)** P: CHM 111 or 1 yr. H.S. C: MA 153 or MA 151	**ENGR 101 (1)**	**ENGR 120 (2)** P: MA 153 **Area V**	**ENGR 121 (2)** P: MA 154 or MA159 (C or better), or placement C: ENGR 120	**ENGR W131 (3)** P: ENG W130 (C or better), or placement
2nd Semester 18 credits	**MA 166 (4)** P: MA 165 (C or better)	**PHYS 152 (5)** C: MA 166	**ENGR 199 (3)** P: ENGR 101, C: ENGR 121, PHYS 152	**COM 114 (3)** (C or better)	**General Education (3)** **Area III**	
3rd Semester 17 credits	**MA 261 (4)** P: MA 166 (C or better)	**MA 351 (3)** P: MA 166 (C or better)	**PHYS 251 (5)** P: PHYS 152 C: MA 261	**ME 250 (3)** P: PHYS 152 C: MA 261	**ENGR 221 (2)** P: ENGR 101, ENGR121	
4th Semester 16 credits	**MA 363 (3)** P: MA 351	**ME 251 (3)** P: ME 250 C: MA 363	**ME 200 (3)** C: MA 261	**ME 252 (3)** P: ME 250 C: MA 363	**CE 203 (4)** P: MA165, ENGR 120 Surveying	
5th Semester 16 credits	**CE 340 (3)** P: ME 251 Hydraulics	**CE 371 (3)** P: ME 252 Structural Analysis	**ME 303 (2)** P: CHM 115, PHYS 251) C: ME252	**ME 293 (2)** P:COM114, ENG W131	**CE 303 (3)** P: CE 200) Route and Construction Surveying	**ECON E 201 (3)** **Area III**
6th Semester 14 credits	**CE 343 (1)** C: CE 340 Hydraulics Lab	**CE 473 (3)** P: CE 371 Theory of Reinforced Concrete	**ME 304 (1)** P: ME 282, ME 303	**CE 392 (3)** P: MA 261 Stochastics	**CE 383 (3)** P: ME 252, C: ME 303 Geotechnical Engineering	**General Education (3)** **Area IV**
7th Semester 16 credits	**CE 350 (3)** Environmental Engineering	**CE 474 (1)** C: CE 473 Theory of Reinforced Concrete Lab	**CE 487 (3) or ENGR 410 (3)** P: CE 473 Civil Engineering Design I	**Tech. Elec. (3)**	**CE 361 (3)** Transportation Engineering	**Tech. Elec. (3)**
8th Semester 15 credits	**Tech. Elec. (3)**	**Tech. Elec. (3)**	**CE 488 (3) or ENGR 411 (3)** P: CE 487 or ENGR 410 Civil Engineering Design II	**General Education (3)** **Area IV**	**General Education (3)** **Area VI**	

Total credit hours: 128

Figure 3: Modified BSCE degree in Civil Engineering

BSCE Degree
Department of Engineering

Proposed Date: Fall 2007
All engineering & technical elective courses must have a combined minimum GPA of 2.0.
Course sequencing follows the academic year, and assumes beginning the program in the Fall Semester.
P = Pre-requisite, C = Co-Requisite or Pre-requisite

For more information visit http://www.engr.ipfw.edu

1st Semester 16 credits	**MA 165 (4)** P: MA 154 or MA 159 (C+), or placement Calculus I	**CHM 115 (4)** P: CHM 111 or 1 yr. H.S. C: MA 153 or MA 151 General Chemistry	**ENGR 101 (1)** Introduction to Engineering	**ENGR 120 (2)** P: MA 153 **Area V** Graphical Communication	**ENGR 121 (2)** P: MA 154 or MA159 (C+), or placement C: ENGR 120 Computer Tools	**ENG W131 (3)** P: ENG W130 (C+), or placement Elementary Composition
2nd Semester 15 credits	**MA 166 (4)** P: MA 165 (C+) Calculus II	**PHYS 152 (5)** C: MA 166 Mechanics	**ENGR 199 (3)** P: ENGR 101 C: ENGR 121, PHYS 152 Intro to Engineering Design	**COM 114 (3)** (C +) Fund of Speech Communication		
3rd Semester 17 credits	**MA 261 (4)** P: MA 166 (C+) Multivariate Calculus	**MA 351 (3)** P: MA 166 (C+) Elementary Linear Algebra	**PHYS 251 (5)** P: PHYS 152 C: MA 261 Heat Electricity and Optics	**CE 250 (3)** P: PHYS 152 Statics	**ENGR 221 (2)** P: ENGR 101, ENGR121 C and C++ Programming	
4th Semester 18 credits	**MA 363 (3)** P: MA 261 MA 351 Differential Equations	**CE 251 (3)** P: CE 250 C: MA 363 Dynamics	**ME 200 (3)** C: MA 261 Thermodynamics I	**CE 252 (3)** P: CE 250 Strength of Materials	**CE 210 (3)** P: MA 165 ENGR 120 Introduction to Geomatics	**General Education Elective (3)** **Area III**
5th Semester 18 credits	**CE 318 (3)** P: ME 200, CE 251, and MA 363 Fluid Mechanics	**CE 375 (3)** P: CE 252, MA 363 Structural Analysis	**CE 315 (3)** P: CE 252 CE Materials	**CE 345 (3)** C: CE 210 Transportation Engineering	**STAT 511 (3)** P: MA 166 Statistical Methods	**ECON E 201 (3)** **Area III** Intro to Microeconomics
6th Semester 14 credits	**CE 319 (1)** P: CE 318 Fluid Mechanics Lab	**CE 365 (3)** P: CHM 115 C: CE 318 Environmental Engineering	**CE 316 (1)** P: CE 315 CE Materials Lab	**CE 380 (3)** P: CE 252 CE 318 Soil Mechanics	**CE 376 (3)** P: CE 375 Design of Concrete Structures	**CE 330 (3)** C: STAT 511 Construction Management
7th Semester 15 credits	**CE 418 (3)** P: CE 318 C: CE 319 Hydraulics	**CE 366(1)** P: CE 365 Environmental Engineering Lab	**CE 487 (1)** P: CE 376 Civil Engineering Design Project I	**CE 381(1)** P: CE 380 Soil Mechanics Lab	**1st Tech. Elec. (3)** **2nd Tech. Elec. (3)**	**General Education Elective (3)** **Area IV**
8th Semester 15 credits	**3rd Tech. Elec. (3)**	**4th Tech. Elec. (3)**	**CE 488 (3)** P: CE 487 Civil Engineering Design Project II	**General Education Elective (3)** **Area IV**	**General Education Elective (3)** **Area VI**	

Total credit hours: 128

Key:

	Math & Science		Freshmen Engineering		Civil Engineering		Mechanical Engineering		General Education

Figure 4: Elective Courses for the Civil Engineering Program
Technical Electives

Civil Engineering Program

Structural Area Courses

Course #	Title	Credit	Department
CE 379	Numerical Methods in Engineering	3	Engineering
CE 468	Experimental Stress Analysis	3	Engineering
CE 475	Design of Steel Structures	3	Engineering
CE 480	Finite Element Analysis	3	Engineering
C E 570	Advanced Structural Mechanics	3	Engineering
MA 510	Vector Calculus (‡)	3	Mathematics

Geoenvironmental Area Courses

Course #	Title	Credit	Department
CE 420	Water Resources	3	Engineering
CE 465	Water and Wastewater Engineering	3	Engineering
CE 478	Foundation Analysis and Design	3	Engineering
GEOL G451	Principles of Hydrogeology (†)	3	Geology
GEOL G406	Introduction to Geochemistry (†)	3	Geology
BIOL 349	Environmental Science (†)	3	Biology

Construction Management Area Courses

Course #	Title	Credit	Department
CE 410	Route and Construction Surveying	3	Engineering
CE 431	Construction Contracting and Specifications	3	Engineering
CE 432	Construction Planning and Scheduling	3	Engineering
SE 520	Engineering Economics	3	Engineering
BUS Z 302	Management of Organizations and People (‡)	3	Business

Transportation Area Courses

Course #	Title	Credit	Department
CE 448	Transportation Planning	3	Engineering
CE 450	Roadway and Pavement Design	3	Engineering
CE 455	Traffic Engineering	3	Engineering
MA 575	Graph Theory (‡)	3	Mathematics

Special Topics

Course #	Title	Credit	Department
CE 412	Geographic Information Systems in Engineering	3	Engineering
CE 435	Introduction to Engineering Systems Design	3	Engineering
CE 490	Selected Topics in Civil Engineering	3	Engineering
STAT 512	Applied Regression Analysis (‡)	3	Mathematics

(†) At least one technical elective course shall be taken from this group.
(‡) Only one technical elective course may be taken from this group.
A maximum of two elective courses can be taken from non-civil engineering courses.

VI) Recommendations for current or future implementations

1) Engineering Economy or systems: it is recommended to adapt Engineering Economy or Systems Engineering course that include engineering economy material to replace Introduction to Microeconomics class.
2) Computational Methods: several schools have listed computational or numerical method in their core curriculum. It is recommended to add an introduction to numerical methods for engineers in one of the freshmen courses. This course is proposed to be an elective course at this time.
3) Computer Tools for Engineers: although none of the schools listed in the survey offer this course in their curricula, however, most of the materials covered in this course is covered in one or several courses in the other schools. It is recommended to keep this course with possible modified in the future to include basic simulations and optimization using computers.

Summary and Conclusions

The total credit hours for the program are 128. This total is within the range of programs in the Department of Engineering (i.e., 126-128) and is the same as the minimum of hours offered by other program. The following table summarizes the proposed changes, degree plan, and the bingo sheet:

1) Proposed Changes:

Remove		Add	
Replacing Courses			
Course	CH	Course	CH
Route and Construction Surveying	3	Fluid Mechanics	4
Stochastics	3	Statistical Applications in Civil Engineering	3
Measurements and Instrumentation	2	Construction Management	3
Changing Exiting Courses			
Material Science and Engineering Mechanics and Materials Lab Reinforced Concrete Lab	4	Civil Engineering Materials (3) and Materials lab (1)	4
Capstone Design Project I	3	Capstone Design Project I	1
Adding/Removing Labs			
Hydrulics Lab	1	Environmental lab *	1
		Soil Mechanics lab *	1
Modifying Names			
Structural Analysis I	3	Structural Analysis	3
Geotechnical Engineering I	3	Soil Mechanics	3
Theory of Reinforced Concrete	3	Design of Concrete Structures	3
Total	25		26

*: new course or part of the original course.

The current modification to the proposed CE curriculum will help the program to be comparable to the CE programs in the state of Indiana and the neighboring region. In addition, it meets the new ABET criteria and give flexibility to students to choose the new science course of their choice. Moreover, the curriculum will not only meets the ABET requirements, but also the knowledge needed for the graduating civil engineers in the region.

Updating and modifying curriculum is continues process. Therefore, the current curriculum should be reviewed and updated continuously to me the need of the region and the new ABET criteria of 2009 and the new resources available at IPFW. It is highly recommend comparing the new modified curriculum to the American Society of Civil Engineers (ASCE) Body of Knowledge (BOK) and come up with recommendations to meet both ABET 2009 criteria and BOK.

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