Accreditation Changes in Civil Engineering Curricula: Addressing the Additional Science Requirement

Thomas R. Dion[1] Dennis J. Fallon[2], and Kevin C. Bower[3]

Abstract – The Accreditation Board for Engineering and Technology (ABET) has promulgated criteria for accrediting engineering programs in the United States under the heading ***ABET Engineering Criteria 2000***.[1] As part of ABET's *Criteria for Accrediting Programs in Engineering* in the United States, ABET has selected an approach of adopting program criteria for engineering disciplines that have been created by parent discipline specific organizations. Once approved by ABET, these program criteria are integrated as part of the accreditation process. One of these Participating Bodies of ABET is The American Society of Civil Engineers (ASCE) which has taken on the role of formulating program criteria specifically for programs specifically dealing with civil engineering. As a result, ASCE has published the ***Civil Engineering Body of Knowledge for the 21st Century—Preparing the Civil Engineer for the Future***.[3] This publication, which supports ***ABET's Engineering Criteria 2000***, has been referred to as the "Body of Knowledge" (BOK) by ASCE's Committee on Academic Prerequisites for Professional Practice.

Effective with the 2008-2009 Accreditation Cycle, Civil Engineering programs must demonstrate that graduates are able to apply mathematics, physics, chemistry, and at least one additional area of science, consistent with the program educational objectives.[2] The reasoning is that ASCE's BOK places increased emphasis on mathematics and science, while recommending a broader background in science. Clearly this provision is intended to assure graduates are able to solve problems in at least one additional area of science, while suggesting biology, ecology, geology/geomorphology, and geospatial representation as possible fields to consider; This paper examines how one institution studied various alternatives, formulated a plan to change the curriculum, and then adopted these curriculum modifications to satisfy this new science requirement.

Keywords: ABET 2000, Curriculum, Additional Science, Geospatial Representation, ASCE BOK.

[1] The Citadel, Dept. of Civil & Environmental Eng, The Citadel, Charleston, SC 29409, diont@citadel.edu

[2] The Citadel, Dean of Engineering, The Citadel, Charleston, SC 29409, fallond@citadel.edu

[3] The Citadel, Dept. of Civil & Environmental Eng, The Citadel, Charleston, SC 29409, kevin.bower@citadel.edu.

INTRODUCTION

During the Accreditation Board for Engineering and Technology's Accreditation Commission Meeting held July 21-22, 2006, criteria affecting accreditation criteria for evaluations scheduled during the 2008-2009 academic year was passed. Effective with this cycle Civil Engineering programs must "…demonstrate that graduates can apply knowledge of mathematics through differential equations, calculus-based physics, chemistry, and at least one additional area of science, consistent with the program educational objectives. " One of the Civil Engineering programs scheduled for re-accreditation during this cycle is at The Citadel. Currently the Civil Engineering Program at The Citadel requires 132 semester hours of credit in order to satisfy requirements to complete an Bachelor of Science degree in Civil Engineering. Of these hours, students take two semesters of Chemistry /Chemistry Lab and also two semesters of Physics/Physics Laboratory to satisfy the previously established science component. Faced with an already heavy credit hour student work load, the Citadel's Civil and Environmental Department was faced with two alternatives to meet this additional science requirement: add another course, or modify/substitute another course to meet this additional science requirement.

During the Annual Civil and Environmental Engineering Faculty Retreat held August 10th and 11th 2006, the Curriculum Committee was charged with looking into how the department might handle this proposed new change in the accreditation requirements. The reasoning behind this new requirement is that ASCE's BOK (BOK-2) places increased emphasis on mathematics and science fundamentals, and it recommends a much broader science background so that future engineers are better prepared to adapt to emerging fields like biotechnology and nanotechnology. Consequently, this provision of the CE Program Criteria is intended to assure that graduates learn and can solve problems in at least one additional area of science. Likely candidates for the "additional area of science" include biology, ecology, geology/geomorphology, and geospatial representation; however, the program has wide latitude to define this curricular area, consistent with its own program objectives."[2]

DEPARTMENT'S CURRENT EDUCATIONAL OBJECTIVES

The Citadel's Department of Civil and Environmental Engineering current Educational Objectives are:

Design:
Graduating students who are successful in engineering based on a course of study focused on design, including a solid theoretical and practical foundation that leads to successful employment in the private and public sectors.

Sustainable Success:
Graduating students who have sustainable career success and participate in leadership roles through demonstration of lifelong learning, effective communication, contributors on multidisciplinary teams, and broad based prospective of engineering and societal needs.

Broad Based Education:
Graduating students who have a broad educational background that leads to good citizenship through leadership, management, decision making and problem solving abilities.

The Design Educational Objective requires students to have a solid theoretical and practical foundation where they can be successful in the public and private sectors. Since all Civil Engineering projects occupy some amount of space on or near the surface of the earth, the engineer must understand the existing site conditions in order to properly design a solution to a given problem. This understanding is fundamental to the design process. Site conditions can include defining the earth's surface through geospatial representation, and therefore is an essential part of our educational objectives.

DEFINING GEOSPATIAL REPRESENTATION

The Curriculum Committee first endeavored to learn how geospatial representation was being defined by other institutions. There are numerous undergraduate and certificate programs in the United States focused on Geospatial Sciences. A representative program at Missouri State University includes a number of courses in the following fields: Geography, Plane Surveying, Air Photo Interpretation, Principles of Cartography, Remote Sensing, Photogrammetry, Introduction to Geographic Information Systems, Geospatial Science, Advanced Plane Surveying, Legal Aspects of Boundary Surveying, Surveying Computations, Thematic Mapping, Satellite Surveying and Navigation, Database Concepts, and Computer Graphics.

Their Minor in Geospatial Sciences includes courses focused on Geography, Interpretation of Aerial Photography, Principles of Cartography, Remote Sensing, Introduction to Geographic Information Science, Photogrammetry, Thematic Mapping, Satellite Surveying and Mapping, Automated Geographic Information Science.

Since the Citadel's Department of Civil and Environmental Engineering is only considering a single course that will provide the appropriate type of subject matter addressing geospatial representation, the committee felt that topics chosen should generally reflect the same types of subject matter encountered if pursuing a degree in this field. As a result, the appropriate material to support The Citadel's Civil Engineering Educational Objectives while providing curriculum continuity are defined as:

Principles of Cartography—Including coordinate systems, topographic and thematic mapping

Advanced Conventional Surveying & Mapping Control—Including Adjustments using Least Squares, Astronomic Observations, and Roadway Alignments

Satellite Surveying and Mapping— Including Theory, Network Design, Data Collection, Processing, Adjustment

Geographic Information Systems— Including Input, Database Management, Geocoding, Spatial Analysis, Thematic Mapping, and Metadata

Remote Sensing—Photogrammetry, Lidar, IFSAR

APPROACH UTILIZED TO INCORPORATE GEOSPATIAL REPRESENTATION INTO THE CURRICULUM

Currently the Department of Civil and Environmental Engineering offers a three credit hour course entitled Civil 207 Geomatics, along with its associated one credit hour laboratory listed as Civil 237. Many of the topics pertaining to geospatial representation are currently covered in these two courses. However, some of the remaining topics are currently addressed in a three credit hour Civil 205 Land Surveying course.

The committee recommended that the faculty who teach land surveying and Geomatics consider revamping these courses where topics pertaining to basic land surveying be confined to the Civil 205 course, and topics reflecting geospatial representation be included in Civil 207 and its associated laboratory. It was also recommended that during this process new course materials be developed to expand the subject matter on least squares adjustments and defining the geoid. As a consequence, the pre-requisite and co-requisite requirements needed to also be evaluated . It was also suggested that a different textbook be considered that not only covers the basic land surveying topics, but also includes information pertaining to Geomatics.

COURSE MODIFICATIONS

During the Summer of 2007 the faculty involved with teaching surveying and Geomatics studied what was being suggested and created some proposed modifications to the curriculum, relative to Civil 205 Land Surveying, Civil 207 Geomatics, and Civil 237 Geomatics Laboratory. These modifications were then coordinated with a new textbook [5].

Civil 205 Land Surveying I Revisions for Fall 2008

I. Course Description: Required of all Civil Engineering sophomores. Linear measurements, leveling, compass and transit/theodolite, total stations, theory of errors, latitudes and departures, areas, stadia, datums, coordinate geometry, construction field control, legal aspects of land surveying and Public Land Surveys.

Three semester hours credit Lecture: three hours

II. Co-requisite Info: All students enrolled in Land Surveying I must have completed or satisfied the following co-requisite requirements :Civil 101—Engineering Drawing , and Co-requisite course: Civil 235 Land Surveying I Laboratory.

III. Course Objectives:

This course draws from previous course work contained in the pre-requisite/co-requisite courses cited above. Students will learn principles of land surveying for both horizontal and vertical control, including theory of errors, types and uses of equipment, and methods of observation. Data collection, reduction, and analysis will also be covered, as well as coordinate geometry, datums, construction field control, and legal aspects of land surveying.

IV. Course Goals:

Upon completion of Civil 205 a student should:

1. Demonstrate the use of mathematics when making surveying computations.
2. Understand ways to organize and assemble pertinent information as well as determine data acceptability and alternatives while meeting realistic constraints.
3. Demonstrate how some surveying related products are used to help solve engineering problems.
4. Know the essential professional and ethical responsibilities of a land surveyor as well as the existence of Minimum Standards for the Practice of Land Surveying in SC.
5. Recognize various tools used in land surveying as well as understand their utilization and application.
6. Recognize the legal aspects of land surveying as well as the Public Land Surveying System, while demonstrating the ability to communicate surveying information in a written format.
7. Recognize construction field control techniques.

Civil 207 Geomatics Revisions for Spring 2009

I. Course Description.

Civil 207 Geomatics

Required of all Civil Engineering sophomores. A course in geospatial representation that includes topographic mapping, advanced adjustments using least squares procedures, map projections, state plane coordinate systems, astronomic control for mapping, Geographic Positioning Systems (GPS), Geographic Information Systems (GIS), remote sensing, and curve alignments. Lecture: 3 hours

Prerequisites: Civil 205 and Civil 235; Co-requisite: Civil 237, 100, and Math 131.

II. Course Goals: Upon the completion of Civil 207 a student should:

1. Conduct office and field procedures relating to topographic mapping.
2. Use least squares procedures to adjust mapping control.
3. Recognize the various map projects and reference datums, while being to compute convert coordinates from one reference system to another.
4. Apply Global Positioning Systems operational theory, as well as design a static network, plan the survey, acquire field data and perform error analysis, and adjust field data.
5. Conduct and analyze astronomic observations for positioning and directions.
6. Identify the use of Geographic Information Systems and recognize how GIS can be created and utilized by multi-disciplinary teams.
7. Recognize various remote sensing systems and the products that they produce (Lidar/Photogrammetry/digital ortho photos).
8. Understand horizontal and vertical curve geometry, nomenclature, and applications.

Civil 237 Geomatics Laboratory Revisions for Spring 2009

I. Course Description:

Civil 237 Geomatics Laboratory

Required of all Civil Engineering sophomores. Applications of principals obtained in Civil 207 through actual field work and office type work. Preparation of a topographic map, Geographic Positioning Systems mapping controls, Geographic Information System applications, and horizontal curve applications.

One semester hour credit Laboratory: two hours

II. Prerequisite Information:

All students enrolled in Geomatics Laboratory must have completed or satisfied the prerequisite requirements concerning the following courses: Civil 205—Land Surveying I, Civil 235—Surveying Laboratory, Civil 207—Geomatics (Co-Requisite)

Civil 237 Geomatics Laboratory Revisions for Spring 2009 (Cont'd)

III. Course Goals: Upon completion of Civil 237 a student should be able to:

1. Conduct office and field procedures relating to topographic mapping.
2. Adjust mapping control using least squares procedures.
3. Apply Global Positioning systems Operational theory, as well as to design a static network, plan a survey, acquire field data and perform error analysis, and adjust field data.
4. Conduct and analyze astronomic observations for positioning and direction.
5. Identify the use of Geographic Information systems and recognize how GIS can be created and utilized by multi-disciplinary teams.
6. Identify horizontal control geometry and nomenclature, while demonstrating an ability to compute and field state a computed curve.

MAPPING COURSE GOALS TO PROGRAM OUTCOMES

These goals were then mapped to BOK Outcomes and Bloom's levels of achievement as shown in Table 1 and 2. Once mapped, the Departmental Assessment Committee was consulted to insure that continuity was being maintained throughout the assessment process, while trying to ensure a seamless change in the overall curriculum.

Table 1 Course Goal Mapping for Geomatics Laboratory Civl 237

Course Goal	*ASCE – BOK Outcome*	*Bloom's Level*
1	Engineering Tools	Comprehension
2	Math and Science	Application
3	Math and Science	Comprehension
4	Engineering Tools	Comprehension
5	Math and Science	Application
6	Engineering Tools	Comprehension
7	Engineering Tools	Knowledge
8	Math and Science	Application

Table 2 Course Goal Mapping for Geomatics Laboratory Civl 237

Course Goal	*ASCE – BOK Outcome*	*Bloom's Level*
1	Engineering Tools	Application
2	Engineering Tools	Application
3	Engineering Tools	Application
4	Engineering Tools	Application
5	Communicate	Application
6	Engineering Tools	Application

CURRICULUM COMMITTEE RECOMMENDATIONS AND DEPARTMENTAL ACTION

After receiving the recommendations from the faculty who teach surveying and Geomatics, The Curriculum Committee in early August 2007, the members agreed to present the recommendations to the full department at its Annual Retreat later that month. During the Retreat, the Chair of the Curriculum Committee presented the recommendations, which were then discussed. One suggestion was to change the Civil 207 proposed co-requisite mathematics requirement of having to be enrolled in Math 131, Analytic Geometry and Calculus, to a pre-requisite where this course must be completed prior to enrolling in Geomatics. The Curriculum Committee subsequently met during the Fall of 2007 and agreed with this recommendation. Consequently, a final presentation was made by the Committee to the departmental faculty, and the proposed modifications were approved as modified by changing the prerequisite requirement. Currently, the faculty who teach surveying and Geomatics are gearing up to implement the newly adopted plan during the Fall of 2008. At that time, ongoing assessment activities will monitor how effective the proposed plan is working, and what other modifications might be in order to improve the curriculum.

REFERENCES

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Thomas R. Dion

COL. Dion graduated from The Citadel in 1968 with a BS degree in Civil Engineering. He earned an MS degree in Civil Engineering from Clemson University in 1973 and was registered as a professional engineer and land surveyor in the state of South Carolina in 1976. He became a full time faculty member of the Civil and Environmental Engineering Department at The Citadel 31 years ago when he began teaching undergraduate students. Part of his departmental duties includes being coordinator of the Civil and Environmental Engineering Department's Capstone Design Course in Engineering Practice as well as the faculty member responsible for a senior level undergraduate site engineering course entitled Subdivision Planning and Design.. Col. Dion formerly served as President of the Section 2000-2001 and is currently serving as Campus Representatives Coordinator for the Southeastern Section of ASEE.

Dennis J. Fallon

Col. Fallon obtained a Bachelor of Science Degree from Old Dominion University. He earned a Master of Civil Engineering and a Doctor of Philosophy from North Carolina State University. He has over twenty years teaching experience and over twelve years industrial and commercial design experience. He previously served as President of the Southeastern Section in 1996-1997 and 2003-2004. Dr. Fallon has received several awards for teaching including the Chi Epsilon James M. Robbins Award for Excellence in Teaching. In addition, he was co-recipient of the Thomas C. Evans Instructional Paper Award for 1990. He is the Dean of Engineering at The Citadel in Charleston, South Carolina.

Kevin C. Bower

Dr. Bower is an Assistant Professor in the Department of Civil and Environmental Engineering at The Citadel in Charleston, SC. Prior to his employment at The Citadel, he worked as an environmental engineer in Akron, Ohio. He received a Ph.D. in Environmental Engineering from The University of Akron and specialized in modeling carcinogenic chemical production in the drinking water distribution system. Dr. Bower was the 2005 Most Outstanding New Faculty at the ASEE –SE Conference and a New Faculty Fellow at the 2004 Frontiers in Education Conference. Dr. Bower is currently pursuing research in ethical and moral development in the engineering profession and how that relates to student learning.