

Design of a Surveying Curriculum to Meet Professional Licensing Needs in New Mexico and Surrounding Areas

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SUMMARY

The Surveying Engineering program at New Mexico State University was started in 1990 to provide college-educated professional surveyors. The program curriculum has undergone several changes over the years, evolving into an ABET accredited Surveying program then into an ABET accredited Surveying Engineering program. To achieve ABET accreditation certain elements must be present in the program curriculum. In addition, the national licensing examinations have undergone changes which US surveying educators must also consider when developing curricula should passing the examinations play a part in their educational mission.. Finally, State of New Mexico and New Mexico State University degree requirements must be fulfilled. These degree requirements are intended to allow students to move freely between educational institutions and to insure that a breadth of education is achieved in each field of study.

When developing a program curriculum, input from members of the profession who will be hiring the graduates of the program are highly valuable. The profession has requested graduates who have a high level of knowledge and ability to solve surveying problems and some fundamental skills in using the tools needed to solve the problems, including field equipment and computers. They also request that graduates have the ability to become licensed surveyors.

The curriculum development process at New Mexico State University then must balance the needs of the profession with the requirements of ABET accreditation, the requirements for the core knowledge needed to pass the NCEES licensing examinations and the requirements imposed by the State of New Mexico and New Mexico State University.

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1. INTRODUCTION

The Surveying Engineering program at New Mexico State University is located in Las Cruces, New Mexico about 50 miles north of both El Paso, Texas, and the US/Mexican border. The program was started in 1990 at the request of the New Mexico Professional Surveyors as a part of an initiative to require a four-year degree as a requirement for professional licensure as a surveyor in the State of New Mexico. Effective July 1, 1995, surveyors seeking professional licensure in New Mexico must have a four-year degree. The curriculum has been continually upgraded (and continues to be upgraded) to reflect the needs of government and private industry employers who hire graduates of the program.

The Surveying Engineering program has three full-time faculty members and occasionally hires part-time faculty, usually to teach a single course or lab. There are between 30 and 50 students in any given semester. The program operates on a two-semester term per year, each term lasting 16 weeks with an additional week for final examinations. Courses are typically 3 semester credits. Many courses come with a practical exercise component referred to as a “lab.” One semester credit of lecture will comprise of 15 hours of classroom contact between instructor and students. One semester credit of lab will comprise of 2-3 hours of contact between instructor and students. Thus a course with 3 semester credits comprising 2 credits of lecture and 1 credit of lab will have 30 hours of lecture and between 30 and 45 hours of lab. The State of New Mexico requires a minimum of 128 semester credits to earn a four-year degree. There is considerable pressure from both the State and the University to keep the degrees at or near the minimum semester credit levels.

The purpose of the Surveying Engineering program is to produce licensed professional surveyors. The program is ABET accredited as an Engineering program and students typically take the NCEES Fundamentals of Surveying exam before or immediately after graduation. In addition, the State of New Mexico and New Mexico State University both have certain requirements placed on four-year degrees. In addition, employers of Surveying Engineering graduates have qualities which they would like to see graduates be able to achieve. Because the requirements from the various influencing factors change, the curriculum is reviewed on a constant basis and changes are made when deemed necessary.

The process to change the curriculum is two-fold. To change the content of a course, a form (called a “flimsy”) must be prepared and sent out to review by the entire university. This requirement exists whenever a new course is proposed, an old course is being deleted, or any wording, prerequisites, course credits, or other changes are being made to the course, no matter how trivial those changes may seem. Others are allowed to give feedback on the

proposed actions. The reviews take place twice a year and no course content can be changed without the review. The purpose of the review is to try to prevent duplication of courses. To change the curriculum, the faculty members rewrite the curriculum, adding or deleting courses, and the curriculum is reviewed by the Department Head and the Associate Dean of Students.

2. EMPLOYER REQUIREMENTS

The Surveying Engineering program at NMSU relies on an Advisory Committee to get feedback from the surveying profession on the qualities that those hiring Surveying Engineering graduates are looking for. This Advisory Committee represents the profession as a whole and members are drawn from a diverse pool of potential employers as possible. The Surveying Engineering Industrial Advisory Committee (SEIAC) meets twice a year and discusses, among other items, survey course curricula and course content. Other roles the SEIAC fill are aiding the Surveying Engineering program in equipment acquisition and funding. The SEIAC currently has 8 members. Members agree to serve a 3 year term and can be appointed for only 2 consecutive terms. The chair of the committee is one of the committee members. The SEIAC meetings are held with Surveying Engineering faculty in attendance. Faculty members are encouraged to add comments and make suggestions during the meetings.

Industry requirements appear to be graduates who are capable and willing to become licensed surveyors in New Mexico and/or other states. To become licensed, graduates must pass a series of written examinations prepared by the National Council of Examiners for Engineering and Surveying (NCEES) which are used by all states to assess fundamental surveying knowledge of examinees. ABET accreditation is highly valued as accreditation shows the program has met a nationally recognized standard and program graduates are eligible for licensure as surveyors in all states of the U.S. In addition, graduates are expected to be capable of running complex survey equipment and software and supervising those field technicians, draftsmen, and others who will work under the graduates. Most graduates become experts at using GPS data collection systems that are applied to construction surveys, land boundary surveys, and control surveys. Graduates are also expected to be able to do the necessary research, analysis, and problem-solving tasks that are involved in day-to-day survey work. Industry would like graduates with high levels of both knowledge and skill but recognize that limits posed by the State of New Mexico limiting degree requirements to a certain amount of credits makes it difficult to graduate the ideal student who has both. The SEIAC has determined, with input and agreement from the program faculty, that the program should stress knowledge over skill, reasoning that high skill levels will come with experience on the job.

3. ABET ACCREDITATION

ABET, formerly known as the Accreditation Board for Engineering and Technology, has several tiers of accreditation. Each tier is comprised of a Commission. There are currently 4

commissions in ABET: the Engineering Accreditation Commission (EAC), the Related Science Accreditation Commission (RSAC), the Technology Accreditation Commission (TAC), and the Computer Science Accreditation Commission (CSAC). Each commission has its own accreditation requirements and review process, although these are relatively the same across the commissions. The Surveying Engineering program at New Mexico State University is accredited under the EAC program. As such, the program must maintain both the general requirements and the program specific requirements to maintain accreditation.

The EAC general requirements for accreditation include 32 semester credits of mathematics and science coursework and 48 hours of engineering (surveying) coursework. The mathematics courses must be calculus or higher and the science courses must include a practical portion or lab. There is an understanding that some humanities coursework will be achieved under general education requirements. The Surveying Engineering program is subject to NMSU and State of New Mexico General Education requirements. These are discussed further in this paper.

The program-specific criterion for surveying and similarly named programs reads:

1. Curriculum

The program must demonstrate that graduates have competency in one or more of the following areas: boundary and/or land surveying, geographic and/or land information systems, photogrammetry, mapping, geodesy, remote sensing, and other related areas.

The Surveying Engineering program at NMSU concentrates on boundary/land surveying with additional required coursework in geographic information systems, geodesy, and photogrammetry. Students may elect to take courses in mapping and remote sensing.

4. NCEES LICENSING EXAMINATIONS

In order to become a licensed surveyor in most, if not all, states in the US, one must first pass a Fundamentals of Surveying examination demonstrating basic surveying knowledge. Passing this exam makes one a “Land Surveyor in Training” or LSIT. After a period of experience working under the direction of a licensed surveyor lasting from six months to four or more years, the LSIT may then be approved to take the Surveying examination and upon passing this examination, professional licensure is usually granted. Since the purpose of the Surveying Engineering program is to produce licensed professional surveyors, the program takes steps to ensure that the core knowledge tested in these exams is being taught in the program.

The Fundamentals of Surveying exam covers 15 topic areas. These areas were selected by a national survey which analyzed the typical knowledge needed by a LSIT and the typical knowledge gained in a four-year surveying degree. The areas are:

- I. Algebra and Trigonometry (11%)
- II. Higher Math (beyond trigonometry) (4%)
- III. Probability and Statistics, Measurement Analysis, and Data Adjustment (5%)
- IV. Basic Sciences (4%)
- V. Geodesy, Survey Astronomy, and Geodetic Survey Calculation (6%)
- VI. Computer Operations and Programming (6%)
- VII. Written Communication (6%)
- VIII. Boundary Law, Cadastral Law and Administration (13%)
- IX. Business Law, Management, Economics, Finance, and
Survey Planning Process and Procedures (6%)
- X. Field Data Acquisition and Reduction (10%)
- XI. Photo/Image Data Acquisition and Reduction (4%)
- XII. Graphical Communication, Mapping (6%)
- XIII. Plane Survey Calculation (10%)
- XIV. Geographic Information System (GIS) Concepts (4%)
- XV. Land Development Principles (5%)

The percentages in parentheses after each topic denote the amount of questions to be found in that topic on the exam.

In addition, NCEES has recently restricted the type of calculators used to take its exams. This restriction grew out of attempts to compromise the exam by copying portions using calculators with QWERTY keyboards or that have scanning capabilities. The approved calculator list included:

- Hewlett Packard – HP 33S
- Casio – FX 115MS or FX 115MSPlus
- Texas Instruments – TI 30X IIS
- Texas Instruments – TI 36X SOLAR

Exam attendees are allowed to use a NCEES supplied booklet of formulae that are attached to the examination. This booklet is available in electronic form on the NCEES website. Since students may not use computers or sophisticated calculators to solve problems in the NCEES examinations, courses must have components that allow students opportunities to be able to solve problems using basic written formulae and hand calculators.

5. STATE OF NEW MEXICO AND NMSU REQUIREMENTS

The State of New Mexico enacted legislation requiring all institutes of higher learning in New Mexico to require a core education curricula that would be transferable to any other institute of higher learning in New Mexico. This statute only applies to public institutions, of which NMSU is one. These requirements are:

- 9 semester credits of communications, including both written and oral communication;
- 3 semester credits of mathematics
- 8 semester credits of laboratory science
- 6-9 semester credits of social/behavioral science
- 6-9 semester credits of humanities and fine arts

The last two items on the list must total 15 semester credits.

NMSU has a built in a degree requirement that all programs must contain 37 credits of general education that meet the State requirements. In addition, the general education credits must be flexible so that students beginning study at one institution in a program may carry those credits into any other program within the institution or transfer the credits to another institution.

The mathematics and science requirements for general education are exceeded by the ABET requirements in those areas. Since ABET requires a minimum of 32 semester credits of mathematics and science, this leaves a total of 24 semester credits of general education that must also be built into the program curriculum. In reality, this is 25 semester credits as the fundamental writing course is 4 semester credits bringing the total credits for communications to 10 credits. Students transferring from an institution where the fundamental writing course is only 3 credits are not required to account for the missing credit.

NMSU also requires 54 credits of upper division coursework (a recent change, yet to be officially approved will reduce this requirement to 48 upper division credits). Upper division coursework is defined as coursework taught at a four-year degree granting institution taught at junior (3rd year) and senior (4th year) levels. Of these upper division credits, 6 must be approved as “Viewing a Wider World” electives that must be taken in subject areas outside of a student’s program. This brings the university requirements to 31 credits hours. All of the General Education courses must come from lists of courses approved by NMSU for General Education.

6. DESIGNING THE CURRICULUM

Beginning from the university requirements, students must have 31 credits of general education coursework, 32 credits of mathematics and science coursework of which 8 credits must be laboratory science, and 48 credits of surveying/engineering coursework. This makes a total of 111 semester credits. However, there is a requirement for a minimum of 128 credits to complete a four-year degree. Thus we have a flexibility of 17 credits in which to place other needed coursework that does not fit into any of the above categories.

The task of deciding the program curriculum falls primarily to the faculty members of that program. However, to avoid appearances of “Ivory Tower” education, the faculty members work with an outside group of advisors selected from government and private industry who

are professional surveyors either through licensure or through job rating (not all Federal government surveyors are licensed as state levels).

First, we note that the written communications and basic sciences required on the NCEES examination are also in the NMSU General Education requirements. The sciences and mathematics required by the NCEES examination are also a part of the ABET requirements. The Surveying Engineering program covers most of the remaining NCEES examination topics within its 48 semester credits of surveying coursework. The GIS knowledge is gained from a required GIS course from the Geography Department.

Communications, mathematics, science, and humanities courses required by the university are undergoing change as a result of a law passed by the State of New Mexico requiring that certain types of coursework be automatically transferable between all New Mexico institutions of higher learning. This has meant that where previously we could require certain specific courses within the university's General Education guidelines, we must now accept any course that fits within the law and count that course towards a Surveying Engineering degree. These changes to comply with the law have been mandated to go into effect during the 2007-2008 academic calendar year.

The NCEES examinations the lead to professional licensure as surveyors require that students and graduates be able to have and understand how to use basic surveying knowledge on many knowledge areas used by practicing surveyors. This requirement ties into the industry requirement that graduates be capable of becoming licensed (which requires passing the NCEES examinations). However, industry also asks that graduates be capable of more sophisticated operations, including use of equipment and computer software, which will allow graduates to step into and easily learn the practical skills needed to become productive surveyors.

To meet the demands, the program contains the necessary General Education requirements, which contain the flexibility to allow students to transfer from other programs or institutions and the necessary mathematics and science base required by ABET. These course must be taught outside the program. Within the program, an ABET requirement of 48 semester credit hours of surveying/engineering are met by providing courses within the program with the option of certain electives from either the Surveying Engineering program or from another engineering program. Since these are the courses that provide the fundamental knowledge needed to pass the NCEES examinations and basic skills requested by employers, these classes are a primarily a combination of lecture and practicum (lab) in which students bring field knowledge and data back into the classroom for research, analysis, and resolution.

As we meet these demands, balancing the needs of each party and the constraints of keeping the course requirements to a minimum, we also understand that the demands are dynamic and will be subject to change. While the curriculum for the Surveying Engineering program does not change every year, it does change over periods no longer that 3 years.

The preliminary curriculum for the 2007-2008 to meet the above mandates has been developed and will undergo review by the department faculty and by the Advisory Committee. The preliminary curriculum is shown in APPENDIX A. Changes to curriculum must be submitted to the University for publication during February 2007. The last change to the curriculum was made during the 2005-2006 academic year.

7. SUMMARY

The curriculum for the Surveying Engineering program at New Mexico State University must meet the demands of employers who want graduates who are capable of becoming licensed surveyors and have high knowledge levels and the ability to acquire high skill levels in surveying. The program is ABET accredited under EAC and has the required ABET elements within the curriculum. The program must also meet State of New Mexico requirements to allow transfer of credit and to limit the amount of credit needed to graduate. These requirements are built into University requirements that each program within the University must follow.

The Surveying Engineering program curriculum undergoes constant review and updating. Courses are altered, added or deleted as required to meet constantly changing needs and requirements. Balancing the needs of the profession with the restrictions and requirements of the academic environment prove to be challenges that are capable of being solved only with constant review and updating of the curriculum.

REFERENCES

ABET, <http://www.abet.org/>

NCEES, <http://www.ncees.org/>

BIOGRAPHICAL NOTES

Dr. Steven Frank is an Associate Professor in the New Mexico State University Surveying Engineering program where he has taught since 1994. He received a BS and MS in Surveying Engineering from California State University at Fresno and a PhD in Surveying Engineering at the University of Maine. His work experience includes 15 years of boundary and construction surveying in the western United States and in Saudi Arabia. He is a past president of the American Association for Geodetic Surveyors, a past president of the New Mexico Professional Surveyors and was chosen as the 2007 Surveyor-of-the-Year by New Mexico Professional Surveyors. He has been involved with FIG since 1999.

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APPENDIX A

DEGREE: Bachelor of Science in Surveying Engineering (Total Credits 130)

Math and Science Courses (32 credits)

GEOL 111G, Survey of Geology, or G EN 160, Geology for Engineers	4
MATH 191, Calculus I	3
MATH 192, Calculus II	3
MATH 280, Linear Algebra	3
PHYS 215, Engineering Physics I.....	3
PHYS 215L, Engineering Physics I Lab.....	1
PHYS 216 and 216L or PHYS 217 and 217L.....	4
STAT 371, Statistics for Engineers and Scientists I	3
Math/Science electives ^{1,2}	8

General Education Coursework (31 credits)

Area I: Communications electives.....	10
ENGL 111	
Writing elective (ENGL 218G recommended)	
Speech elective (COMM 265 or COMM 256 recommended)	
Area II: Mathematics (above requirements exceed GE requirements)	
Area III: Laboratory Science (above requirements exceed GE requirements)	
Area IV: Social/Behavior Sciences electives ...	6-9
ECON 215 or ECON 252 recommended	
Area V: Humanities and Fine Arts electives....	6-9
Viewing a Wider World electives ³	6

Surveying Engineering Coursework (49 credits)

SUR 222, Plane Surveying	3
SUR 285, Photogrammetry.....	3
SUR 292, Public Land Survey System Boundaries	3
SUR 312, Legal Principles of Boundary Surveying	3
SUR 328, Principles and Practices of Construction Surveying	3
SUR 330, Computer Applications of Surveying.	3
SUR 351, Introductory Survey Measurements, Analysis, and Adjustments	3
SUR 361, Introduction to Geodesy	3
SUR 401, Ethics and Professionalism in Surveying and Mapping	3
SUR 450, Senior Project.....	1
SUR 451, Advanced Survey Measurements, Analysis, and Measurements	3
SUR 452, Land Development Design.....	3
SUR 461, Introduction to Satellite Geodesy	3
Engineering electives ⁴	9
Senior elective ⁵	3

Other Coursework (19 credits)

C E 451, Engineering Economy and Law, or I E 451, Engineering Economy	3
GEOG 381, Cartography and GIS.....	3
OEDG 109, Computer Drafting Fundamentals ..	3
SUR 101, Introduction to Surveying.....	1
Computer programming elective (CS 167 recommended)	3
Electives	6

¹ Mathematics electives: MATH 291, MATH 377, MATH 391, MATH 392, or MATH 480

² Science electives must be approved General Education lab science courses

³ One Viewing a Wider World elective recommended from the College of Business Administration and Economics

⁴ Approved Surveying or Engineering courses

⁵ Senior electives: SUR 410, SUR 412, SUR 462, SUR 464, and SUR 485

⁶ Approved Surveying or Engineering courses, approved business courses, or approved technical courses.