

CORE Knowledge in Surveying: Initial Investigations

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SUMMARY

Curriculum development is a primary goal of FIG Commission 2. Towards that end, identifying the knowledge that aspiring surveyors should learn (core surveying knowledge) in a model curriculum would be beneficial and relevant. There is a movement underway within the United States to do just that. There is also great interest within FIG Commission 2 to do the same. Some efforts into identifying core surveying knowledge have been made. The US National Council of Examiners for Engineers and Surveyors (NCEES) has developed a list of surveying knowledge that is tested in the national Fundamentals of Surveying examination. Joshua Greenfeld and Laramie Potts have proposed a body of knowledge development based on US ABET accreditation criteria which would be more flexible than the NCEES approach. This approach is based upon the American Society of Civil Engineering (ASCE) plan which is also described in this paper. Finally, there is a GIS Core Knowledge study developed by the University Consortium for Geographic Information Science (UCGIS) which is looked at as a third approach for developing core knowledge. How are these differing approaches useful in developing a core surveying knowledge? What considerations should be taken to insure that the knowledge is useful and has the flexibility to be adapted by different sub-disciplines within surveying and by different customs among different nationalities? Some possible answers to these questions are provided in the later part of this paper.

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1. INTRODUCTION

One of the objectives of FIG Commission 2 (Professional Education) is curriculum development. This issue is addressed in Commission 2 Working Group 2.1:

Quality curriculum and instruction are - as they have always been - the bedrock of education and the way to developing thoughtful and fulfilled professionals. The society, science and technology around our profession are changing rapidly. These changes continuously generate new educational and training needs, which should be responded by educators to ensure that their learners gain knowledge as effectively and efficiently as possible.

To this end, thoughts of developing a publication of fundamental knowledge that surveying professionals should have and which should be contained in survey curricula are underway within the commission. Initial investigations into this topic by the author have revealed several have been made among sources available within the United States. While we are sure that other sources must exist, they are unknown to the author and have not yet been investigated.

The first source comes from the national examination that aspiring surveying professionals must master to become licensed professional surveyors in the US. This examination tests the fundamental knowledge that professional surveying interns should minimally have in order to qualify as professionals. The second source is a proposal presented at the North American Surveying and Mapping Educators Conference in Big Rapids, Michigan, in July of 2007. This approach is based partially on the US ABET accreditation process that surveying/geomatics programs undergo in the US. The third source is the recently published UCGIS Body of Knowledge which is geared for GIS practitioners. The fourth source investigated is the ASCE publication Civil Engineering in the Twenty-First Century, another area that is related to surveying. Each of these sources represent a source of information that may be useful in compiling a publication of fundamental surveying knowledge which can then be used by academics and professionals to design and implement curricula that reflect the professional practice of surveying.

The challenge in these approaches is that not all areas of surveying will require the same levels or even the same kinds of knowledge.

2. NCEES FUNDAMENTAL SURVEYING KNOWLEDGE

National Council of Examiners for Engineering and Surveying (NCEES) tests US surveyors aspiring to become professional surveyors with an examination titled the “Fundamentals of Surveying” (FS). The exam tests applicants on the basic knowledge required to be minimally proficient at surveying. Successful examinees who have met all of the other requirements then become Land Surveyors in Training (LSITs) and typically serve a 2 to 4 year internship prior to becoming eligible to sit for the Professional Surveyor (PS) examination. The knowledge tested on the FS examination is shown in Table 1 along with the percentage of questions in each topic area that will normally appear on the examination.

Knowledge Area	Percentage of Questions on Exam
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%

Table 1. NCEES Fundamental Knowledge

Each of the 15 NCEES knowledge areas are further broken into specific topics ranging from 6 to 30 topics per knowledge area. Full details of the examination specifications can be found at http://www.ncees.org/exams/fundamentals/fs_exam_specs.pdf. The NCEES knowledge areas are found within the curricula of most US surveying/geomatics programs.

3. GREENFELD AND POTTS SURVEYING BODY OF KNOWLEDGE

Drs. Joshua Greenfeld and Laramie Potts propose a model for a Surveying Body of Knowledge based upon the US ABET Learning Outcomes criteria (Greenfeld and Potts, 2007). A schematic of the Greenfeld and Potts proposal is found in Figure 1.

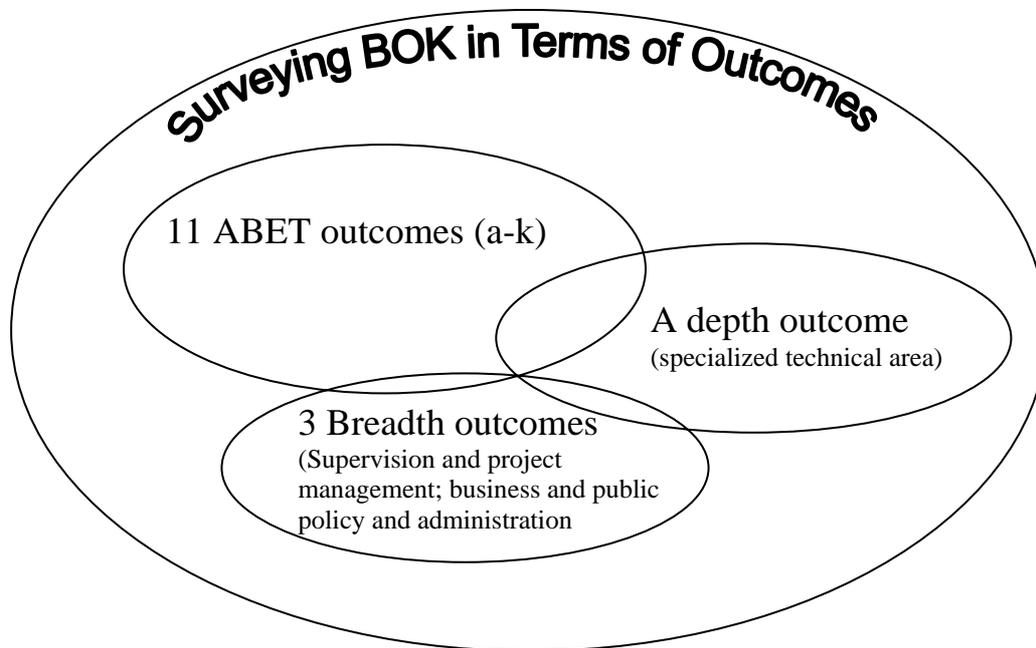


Figure 1. The Body of Knowledge for surveying in terms of outcomes.

The ABET Learning Outcomes have 11 criteria (called the ABET a-k criteria) that must be met by all ABET accredited 4-year professional-level surveying/geomatics programs. The criteria are listed in Table 2.

In addition to the ABET a-k Learning Outcomes criteria, Greenfeld and Potts suggest added in-depth knowledge of a particular area of surveying/geomatics practice and 3 areas of knowledge in business and management.

The added three breadth knowledge areas proposed are as follows:

- An understanding of the elements of supervision and project management
- An understanding of business and public policy and administration fundamentals
- An understanding of the role of the leader and leadership principles

The Greenfeld and Potts proposal is a much broader approach than the NCEES Fundamentals of Surveying Knowledge. It seeks to encompass It is also loosely based on the American Society Of Civil EngineerS (ASCE) Body of Knowledge discussed below.

- (a) an ability to apply knowledge of mathematics, science, and engineering
- (b) an ability to design and conduct experiments, as well as to analyze and interpret data
- (c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
- (d) an ability to function on multi-disciplinary teams
- (e) an ability to identify, formulate, and solve engineering problems
- (f) an understanding of professional and ethical responsibility
- (g) an ability to communicate effectively
- (h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
- (i) a recognition of the need for, and an ability to engage in life-long learning
- (j) a knowledge of contemporary issues
- (k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Table 2. ABET a-k Learning Outcomes Criteria

4 ASCE BODY OF KNOWLEDGE

The American Society of Civil Engineers (ASCE) has published a book titled “Civil Engineering Practice in the Twenty-First Century: Knowledge and Skills for Design and Management.” The book has 12 chapters and contains 263 pages including references. The first chapters of the book are devoted to a look at the evolving nature of civil engineering, the history, consequences and careers of civil engineering. The later chapters detail knowledge area in the following areas:

- Management
- Critical Thinking
- Communication
- Government
- Economics and Finance
- Law
- Professional Practice and Ethics

Each of these chapters treat the knowledge areas and associated skills broadly specifying examples of how the knowledge is used and/or is important. This approach differs from the preceding examples in that specific knowledge of things such as road design, bridge design, or construction management is not listed in the book. The broad approach seems to reflect the broad role of civil engineering and the many avenues of practice than civil engineers can pursue.

4. UCGIS BODY OF KNOWLEDGE

The University Consortium for Geographic Information Science (UCGIS) has compiled a Body of Knowledge manual published by the Association of American Geographers (AAG). The UCGIS Body of Knowledge is presented at 3 levels. The first level contains knowledge areas, the second level is topic areas in each of the knowledge areas and the third level is specific knowledge within the topic area. An example of this structure is shown in Table 3.

Analytical Methods

- AM1 Academic and analytical origins
 - 1-1 Analytical foundations
 - 1-2 Analytical approaches
- AM2 Query operations and query languages
 - 2-1 Set theory
 - 2-2 Structured Query Language (SQL) and attribute queries
 - 2-3 Spatial queries
- AM3 Geometric measures
 - 3-1 Distances and lengths
 - 3-2 Direction
 - 3-3 Shape
 - 3-4 Area
 - 3-5 Proximity and distance decay
 - 3-6 Adjacency and connectivity

Table 3. UCGIS Body of Knowledge

The UCGIS Body of Knowledge contains 10 knowledge areas, some of which share a commonality with knowledge areas of surveying/geomatics. The 10 knowledge areas are:

- Analytical Methods
- Conceptual Foundations
- Cartography and Visualization
- Design Aspects
- Data Modeling
- Data Manipulation
- Geocomputation
- Geospatial Data
- GIS&T and Society
- Organizational & Institutional Aspects

The UCGIS approach is a detailed listing of all the knowledge topics deemed fundamental to GIS practitioners. In this approach, it is similar to the NCEES Fundamental Knowledge model. It gives specific topics with detail on the level of knowledge needed.

5. CONSIDERATIONS IN DEVELOPING A SURVEYING BODY OF KNOWLEDGE

The NCEES approach is useful for those preparing to take the Fundamentals of Knowledge examination in the US to continue in their process of becoming licensed surveyors. It focuses on the basic knowledge tested in the exam. However, not all of this knowledge is used by all surveyors in the US. Surveyors who do not practice in areas requiring licensure typically do not take the exam. The knowledge that these surveyors – geodetic surveyors, land managers, land valuers, etc. – use is not presented in the listed data.

The level of detail of core surveying knowledge would differ between sub-disciplines. Knowledge, in general, is ever-evolving and is constantly being updated. There can be assumed to be certain basic language, mathematical and scientific knowledge that underlie core surveying knowledge. These, too, would vary by sub-discipline.

To list core knowledge in too great detail would make portions of that knowledge certain to be obsolete at some future date. As knowledge is tied to skills, as skills become obsolete, so does the knowledge to perform those skills. For example, with the wide-spread acceptance of computers and computing technology, many older methods of surveying computations are rarely, if ever, practiced today. So core knowledge must be tested for its durability and against its dependence on current technology.

To define core surveying knowledge too broadly would lead to misinterpretation, misunderstanding, and disagreement on what the knowledge actually comprises. Broad definitions must include enough detail that those attempting to implement core surveying knowledge can do so with the intensity and flexibility needed for their situation.

6. CONCLUSIONS

The development of a list of core surveying knowledge would be useful for the development of surveying education curriculum. Given the wide range of skills that surveyors use globally, there may exist a wide range of knowledge that surveyors use in their professional decision-making. Any list of core knowledge would need to be defined with independence from current technology, with flexibility to be implemented over a range of surveying sub-disciplines, and with enough substance to lead to general agreement within the surveying community.

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BIOGRAPHICAL NOTES

Steven Frank is an Associate Professor in the Engineering Technology and Surveying Engineering Department at New Mexico State University. He received his Bachelors and Master degrees from California State University, Fresno, and his PhD from the University of Maine. He is a licensed professional surveyor. He is a past president of the New Mexico Professional Surveyors and the American Association for Geodetic Surveyors. He is the editor of Surveying and Land Information Science.

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