Will Ten Pounds Fit into a Five Pound Bag?

Allen C. Estes, Ronald W. Welch, Karl F. Meyer
United States Military Academy

Abstract

Through the formal development of Policy 465, the American Society of Civil Engineers has defined the Body of Knowledge (BOK) that describes the knowledge, skills and attitudes necessary to become a licensed professional engineer (ASCE, 2004a). The BOK is presented in the form of 15 outcomes that prescribe the necessary breadth and depth of knowledge required for a practicing civil engineer. The levels of competence for these outcomes are defined as recognition, understanding, and ability. The attainment of the BOK is expected to occur through a broad undergraduate education, specialized education at the masters level, and practical experience during the pre-licensure and post-licensure periods. As the policy comes to fruition, draft commentaries are being published that provide more specific guidance and elaborate on the intent of the BOK outcomes.

The BOK outcomes are closely linked to the accreditation criteria (ABET 2004) for ABET accredited civil engineering programs. The draft commentary which provides guidance to civil engineering program ABET evaluators (ASCE 2004b) is ambitious in what undergraduate civil engineering programs are expected to achieve. The requirements include for example, "an understanding in most of the following: biology, geology/geomorphology, engineering economics, mechanics, material properties, systems, geospatial representation, and information technology." There is an increased emphasis on ethics, leadership, social awareness, political understanding, public policy, and business practice. The outcome that requires an understanding of asset management suggests the use of tools and techniques that include "design innovations, new construction technologies, materials improvements, geo-mapping, database management, value assessment, performance models, web-based communication, and cost accounting." There is a clear emphasis on breadth at the undergraduate level with much of the specialized knowledge deferred to masters level education.

The United States Military Academy (USMA) has one of the more broad-based curricula in comparison to other undergraduate ABET-accredited Civil Engineering programs in the U.S. The program requires 142 credit hours before counting military science and physical education. Outside of the math, science and engineering courses, every student takes English composition and literature (3 semesters), world or U.S. history (two semesters), psychology, economics, philosophy, foreign language (2 semesters), political science, geography, international relations, leadership, military history (2 semesters), and constitutional/military law. The program is so broad that it barely satisfies the minimum accreditation requirements in the more technical civil engineering areas.

Because of the unique nature of the USMA Civil Engineering program, West Point joined the ASCE Curriculum Committee, a sub-committee of Curriculum Committee of the Committee on

Academic Prerequisites for Professional Practice (CAP^3) and volunteered to be a test site for implementing the BOK into the curriculum. The purpose of this paper is to provide an initial assessment as to how well the current West Point Civil Engineering program meets these broad-based, breadth requirements expressed by ASCE (2004b). The shortfalls have been illuminating in assessing the reasonableness of the proposed criteria as well as identifying where the West Point curriculum may need to change.

I. Introduction

In a landmark effort to recognize that the civil engineering profession is growing increasingly complex while the number of credit hours in a typical undergraduate civil engineering curriculum is decreasing, ASCE adopted Policy 465 in October 1998 which stated that the masters degree was the first professional degree for the practice of civil engineering. Recognizing that one of the characteristics of a profession is a body of knowledge (BOK), the ASCE Task Committee on Academic Prerequisites for Professional Practice (CAP^3) that was charged with implementing Policy 465 created a Body of Knowledge subcommittee. The Body of Knowledge (BOK) describes the knowledge, skills and attitudes necessary to become a licensed professional engineer. This BOK committee drafted *Civil Engineering Body of Knowledge for the 21st Century* (ASCE 2004a), which defines the BOK in terms of 15 outcomes and prescribes the degree of competency to be attained from formal education and experience prior to obtaining a professional license. The BOK committee was disbanded and the Curriculum Committee, Accreditation Committee, Fulfillment and Validation Committee, and Licensing Committee of CAP^3 were formed to implement the BOK by developing curricula, establishing accreditation criteria, and coordinating with licensing jurisdictions. The work of these committees will proceed simultaneously and the implementation is expected to take two decades with intermediate milestones planned along the way

The charge of the Curriculum Committee is to coordinate the development of new undergraduate and graduate curricula that are compatible with the BOK (ASCE 2004c). This includes finding existing curricula that already contain elements supportive of the BOK and share what is learned. The approach is to find a diverse range of universities that are willing to serve as design partners and develop model curricula that both incorporate the BOK and meet the needs of all universities whether they be public or private, large or small, research-focused or teaching-focused. To date, 18 universities ranging from Bucknell and Norwich to Penn State and the University of Nebraska have volunteered to participate. The committee formed in August 2003 and is scheduled to issue a final report that provides curriculum implementation strategies, suggests revisions to the BOK, and offers possible BOK-compliant curricula with commentaries in December 2005. The United States Military Academy joined the partnership in October 2004. The purpose of this paper is to describe the current status of the BOK, the nature of the West Point civil engineering curriculum, the reasons why West Point joined this effort, and the initial assessment as to how well this program meets the BOK requirements. The shortfalls are illuminating in assessing the reasonableness of the proposed criteria as well as identifying where the West Point curriculum may need to change.

II. Body of Knowledge

The BOK is presented in the form of the 15 outcomes shown in Table 1 that prescribe the necessary breadth and depth of knowledge required for a practicing civil engineer. The BOK outcomes 1 – 11 are deliberately identical to ABET outcomes 3a-k listed in the criteria (ABET 2004) for accrediting civil engineering programs. Outcome 12 focuses on specialization in a particular area of civil engineering. Outcomes 13 through 15 deal with leadership, business policy, and management which are not areas where engineering programs traditionally focus. As the policy comes to fruition, draft commentaries are being published that provide more specific guidance and elaborate on the intent of the BOK outcomes. Unlike the ABET criteria, the BOK prescribes three levels of competency for these outcomes that are defined as recognition, understanding, and ability (ASCE 2004a) where:

- ***Recognition*** represents a reasonable level of familiarity with a concept. At this level, the engineer is familiar with a concept, but lacks the knowledge to specify and procure solutions without additional expertise. For example, an engineer might recognize that a particular architectural plan poses significant construction difficulties without having the expertise to devise improved construction or design alternatives.

- ***Understanding*** implies a thorough mental grasp and comprehension of a concept or topic. Understanding typically requires more than abstract knowledge. For example, an engineer with an understanding of professional and ethical responsibility should be able to identify and to communicate ethical issues arising from a practical case study.

- ***Ability*** is a capability to perform with competence. An engineer with the ability to design a particular system can take responsibility for the system, identifying all the necessary aspects of the design, and match objectives with appropriate technological solutions. As an engineer develops, the engineer's abilities also develop so that more challenging and difficult problems can be solved.

The reasoning behind the levels of competency is that attainment of the BOK is expected to occur through formal education and practical experience during the pre-licensure and post-licensure periods. Figure 1 shows where each level of BOK competency is expected to be attained. For the portion of the BOK that is expected to be achieved through formal education, the job of the Curriculum Committee is to define the expected relative contributions of the undergraduate and masters degree educations and to design curricula that support this.

III. Why Get Involved Now

The United States Military Academy at West Point is a public university with a student population of approximately 4,000 undergraduates. Upon graduation, every student is commissioned as an officer in the U.S. Army. USMA offers majors in 32 disciplines, six of which are ABET accredited engineering majors. West Point confers only a bachelor's degree and has neither the ability nor the desire to start a masters program in engineering. The decision by the West Point civil engineering program to join the curriculum design partnership effort was based on the following:

- This project is not a passing fad; it appears that it is really going to happen. ASCE has committed considerable time, effort, and talent to change the requirements for

professional licensure and raise the bar for the profession. While the obstacles are formidable, there is a plan to work with universities, the accreditation board, the state licensing jurisdictions, and the other professional societies over the next two decades to achieve this goal. Engineering education is important and West Point wants to be part of the process.

- The United States Military Academy has one of the more broad-based curricula relative to other undergraduate ABET-accredited Civil Engineering programs in the U.S. and therefore has a unique ability to contribute. The program requires 142 credit hours before counting military science and physical education. Outside of the math, science and engineering courses, every student takes English composition and literature (three semesters), world or U.S. history (two semesters), psychology, economics, philosophy, foreign language (two semesters), political science, geography, international relations, leadership, military history (two semesters), and constitutional/military law. The program is so broad that it barely satisfies the minimum accreditation requirements in the more technical civil engineering areas. The BOK shortfalls in the USMA CE program will be illuminating in assessing the reasonableness of the proposed criteria. If the broadest program in the country has trouble meeting the criteria, it means that other more specialized CE programs would be particularly challenged. On the other hand, the USMA program may provide an example that demonstrates the proposed criteria are doable.
- The West Point faculty is also unique in that approximately 60% are military officers with six to eight years of service who obtain masters degrees from top-notch schools, teach for three years, and return to duty in the field Army. Professional licensure is a critical area of concern. Currently, many of the military faculty obtain their PE licenses prior to attending graduate school. Their Corps of Engineers duties and strong undergraduate backgrounds provide the necessary experience and expertise to sit for and pass the exam. Since accreditation criteria require a PE license to teach any course with design content, the ability to obtain a professional registration an important faculty selection criterion. The requirement to have a Masters degree or equivalent prior to sitting for the PE exam presents some unique challenges in obtaining qualified faculty members.

IV. Nature of USMA

The operational concept for the USMA (USMA 2002) academic program poses the questions, "What will our commissioned officers need to know in order to lead the Army in the years ahead? How will they integrate their skills and knowledge into a self-concept that reinforces their professional obligations as Army officers? How can the United States Military Academy educate its young men and women for a rapidly changing world?" The answers lie in the ten academic program goals that enable graduates to meet the overarching goal:

"Graduates anticipate and respond effectively to the uncertainties of a changing technological, social, political, and economic world." (USMA 2002)

"Upon achieving this overarching goal, graduates will be able to:

- think and act creatively,
- recognize moral issues and apply ethical considerations in decision-making,

- listen, read, speak, and write effectively,
- demonstrate the capability and desire to pursue progressive and continue intellectual development, and demonstrate proficiency in six domains of knowledge:
  - Engineering and Technology
  - Math and Science
  - Information Technology
  - History
  - Culture
  - Human Behavior"
- continue to develop intellectually (USMA 2002)

These academic goals are attained before considering the goals of any major, which explains why 30 core courses (not including military science and physical education) are required to achieve them. A typical major has only 10 additional courses that other students are not required to take. The civil engineering major requires 14 additional courses above the core in order to meet the minimum acceptable standards of an accredited civil engineering program. Civil engineering majors must overload for at least three or four semesters compared to the non-engineering majors. This makes adding any additional courses to expand coverage of the BOK very difficult. The West Point paradox is that while this broad-based curriculum probably makes USMA more compliant with the BOK, the inflexibility of the core curriculum and the paucity of courses allocated to the major will make any necessary changes more difficult to implement.

V. How USMA is the Same… and Different

In many respects, the USMA CE curriculum is indistinguishable from any other school in the country. Students start with the standard regimen of calculus-based math (four semesters), chemistry (two semesters) and physics (two semesters). Basic engineering theory is provided through Statics, Dynamics, Fluids, and Mechanics of Materials. The program requires courses and a laboratory experience in the four sub-disciplines of Structures, Geotechnical, Hydrology and Hydraulics, and Construction Management. A depth component in Structures is provided through required courses in Structural Analysis, Steel Design, and Reinforced Concrete Design. Additionally, there is a mandatory Capstone design course as well as a widely subscribed program of Independent Study projects. The three elective offerings are mostly in the area of structural or environmental engineering. Thermodynamics and Electrical Engineering provide engineering breadth outside the civil discipline.

A key difference from other institutions in that all students have a full scholarship and are fully expected to graduate in four years. The summers are filled with military training and summer school is only an option for those who fail a course. The large core curriculum requires more humanities courses than most other engineering programs. Figure 2 reflects a benchmarking effort that compares the number of semester credit hours in the humanities and basic science areas at USMA to those required in some other prominent civil engineering programs. Certainly other schools do not require four semesters of military science and physical education. Considering this is a military academy, it is not surprising that there are other mandatory activities that contribute to the BOK – particularly in those outcomes involving management, communication, ethics, and leadership. The cadet honor code is well known: "a cadet does not

lie, cheat, or steal or tolerate those who do." Students receive 13 hours of formalized instruction on the honor code upon entry to the Academy and several hours of reinforcement training in their upperclass years. There is also mandatory instruction on values education, ethics, and respect outside of the formal curriculum. Students are organized into cadet regiments, battalions, companies, platoons and squads with cadet leaders and staff positions designated at each level. The cadet chain of command provides a unique leadership laboratory not found at most civilian universities. The upperclass students plan and lead the summer military training for the cadets in the lower classes. Other summer military training involves students serving as platoon leaders and drill instructors in real Army units throughout the world. Virtually all of these duties require students to write reports and speak in front of groups of people – often in the form of teaching classes, preparing briefings, or issuing orders.

VI. The Initial Mapping Experience

The first task after joining the CAP^3 Curriculum Committee was to map the USMA curriculum to the 15 BOK outcomes using the defined terms: O- No Competency, R-Recognition, U-Understanding, and A-Ability. The analysis was conducted independently by three senior faculty members who have taught most of the courses in the CE curriculum and who are very involved in curriculum development and course management within the civil engineering division. The activity was not new as some assessment of the contribution of courses in the curriculum to achieving outcomes 1 through 11 had already been done in preparation for accreditation visits. After generating independent assessments, the faculty team met, consolidated and compared their respective results, discussed the reasoning behind the ratings, and made changes when appropriate. Changes were typically made when one team member's reasoning was particularly compelling or one rating included a key consideration ignored by the others. The results for outcomes 1 though 7 are shown in Table 2 where each faculty member's rating of O, R, U, or A is listed in each box. Each box represents the contribution of a specific course or activity in the student's four year West Point experience to a specific BOK outcome. Blank cells indicate that nobody felt that the specific course contributed to attainment of a particular outcome.

Although the information is only based on expert opinion, it represents a good start toward an initial assessment. Obviously the judgment regarding courses taught within the CE program is more reliable than that with respect to those courses taught outside the department. The average of the three faculty members' final ratings comprised the score for the contribution of a specific course or activity to an individual BOK outcome. Weighted averages were useful in determining the degree to which the entire curriculum contributes to a specific outcome, relative to the others. In this analysis, the curriculum contributed most to Outcome 7 (Ability to communicate effectively), since virtually every course requires students to communicate thoughts or problem solutions orally or in writing. The overall attainment of an outcome competency after completing the entire curriculum became more of a judgment call. There may be ten courses that contribute to attainment of *recognition* and *understanding* is finally achieved through a Capstone design course. A numerical manipulation of averages was not helpful in making this assessment.

After considerable discussion, the attainment of each BOK outcome was assessed from the combined contribution of courses and other activities in the student's four-year experience. The results are shown in Figure 3 where the ratings reflect, for example, that the USMA CE majors

upon graduation are fully able to attain *recognition* and *understanding* competency in the design of a system and are about 20% of the way to *ability* which entails being able to design an actual real world system applying sound engineering judgment. This final 20% is largely attributable to the Capstone Design course which incorporates a real structure and a genuinely open-ended design problem. Prior to that, all of the student designs, even in steel and concrete classes, were straight forward and had most of the ambiguity removed.

This same analysis was performed for the other BOK outcomes. The USMA CE majors graduate with full competence in many of the engineering software packages that they have used in the classroom. Their *ability* to use spreadsheets, mathcad, drawing programs, Microsoft Project, watershed modeling software, structural analysis software, and the internet rivals the competence of most currently licensed engineers. In fact, many engineers in a design shop rely on the newer graduates to show them how to use the newest software. The USMA graduate exceeds what is expected from the undergraduate experience in the BOK in the areas of communication and leadership, largely due to the additional opportunities they have to practice both in realistic settings.

The areas where USMA students fall short according to the initial assessment are in Outcomes 2 (Experiments, Analyze and Interpret), 5 (Solve Engineering Problems), 12 (Specialized Area), and 9 (Lifelong Learning). The BOK expects that the undergraduate education will provide attainment of *ability* for outcomes 2 and 5. Most of the experiments that USMA students conduct are in a controlled laboratory environment and are canned exercises. The instructor and the students already have a good idea of what the results are supposed to be. Most student experiments lack the complexity and uncertainty found in a real world engineering situation. Similarly, many student engineering problems contain assumptions and simplifications that do not model real world complexity. The solution is not necessarily a change in the West Point curriculum, but perhaps a change in the expectation of what an undergraduate education is realistically supposed to achieve. Despite the attempted depth in the Structures sub-discipline of civil engineering, there is not sufficient coverage to attain the *ability* competency in a specialized area. That will need to be left to a graduate program. While the USMA CE program prepares students for life-long learning, full understanding will not occur until either graduate school or work experience when they will truly appreciate how much they still do not know.

VII. Suggested Changes Based on Committee Efforts

The Curriculum Committee met in early December 2004 to compare results among the curriculum design partners, discuss issues, and monitor progress towards a final report. The most difficult aspect of the mapping exercise was a problem encountered by other universities participating in this same project. The terms *recognition, understanding* and *ability* mean different things to different people, despite the attempts at a formalized definition. The Curriculum Committee members struggled with this during telephone conference calls and during the face-to-face meeting in December in Reston.

Because educators are familiar with Bloom's taxonomy as an acceptable way to communicate increased complexity and attainment in cognitive thought, it was suggested that Bloom's prescribed levels (knowledge, comprehension, application, analysis, synthesis and evaluation) be

incorporated into the definitions of recognition, understanding and ability. The Curriculum Committee decided to suggest to CAP[3] the use of a mixture of terms from both Bloom's taxonomy (Bloom *et.al.* 1956) and a revised Bloom's taxonomy (Krathwohl 2002) to establish the three levels of BOK competency. The levels R (recognition), U (understanding), and A (ability) were replaced by levels 1, 2, and 3, respectively as defined below.

- ***Level 1*** – Retrieve relevant knowledge from long term memory and understand the meaning of oral, written, graphic, and other instructions. Abilities demonstrated at this level typically include, but are not limited to, recognizing, recalling, interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explaining. Attitudes especially supportive of this competence level are curiosity, respect, thoroughness. Level 1 represents familiarity with concepts.

- ***Level 2*** – Apply a procedure appropriate to a given situation, break material into constituent parts, and how the parts relate to one another and to an overall purpose, structure, facility, or system. Abilities demonstrated at this level include, but are not limited to, executing, computing*, simulating*, discovering*, evaluating*, implementing, differentiation, organizing, and attributing. Attitudes especially supportive of this competence level are confidence, persistence, and thoughtfulness. Level 2 means application of concepts.

- ***Level 3*** – Exercise judgments based on criteria and standards and synthesize elements to create a site/situation specific or novel, coherent structure, facility, system or products. Abilities demonstrated at this level include, but are not limited to, checking, evaluating*, critiquing, designing*, generating, combining*, rearranging*, revising*, planning, recommending*, producing, operating*, and maintaining. Attitudes especially supportive of this competence level are commitment, fairness, integrity, intuition, judgment, self-esteem, sensitivity, and tolerance. Level 3 is performing with competence.

Bloom's taxonomy defines actions for the cognitive domain and not all of the outcomes neatly fall into the cognitive domain. The verbs with an asterisk were added as they commonly occur in engineering practice. Because so many faculty members rely on Bloom's taxonomy for the creation of course objectives and lesson objectives for the curriculum that will ultimately lead to BOK competency, using Bloom's classification to define the levels of competency is a logical approach. It is hoped that these definitions will provide additional clarity. These revised definitions resulted in only minor changes to the mapping of the USMA curriculum shown in Table 2.

The Curriculum Committee addressed the level of knowledge, skills, and attitudes obtained through the bachelor's program based on the revised definition of the three competency levels. The discussion included the degree to which additional experience prior to or after formal education would improve the desired knowledge, skills, and attitudes; what level of competency should be covered by the bachelor's education as opposed to the masters degree; and what reasonably should be accomplished at the bachelors level. The changes resulting from this discourse are shown in Figure 4.

The competency required for Outcome 1, the Technical Core, was reduced to Level 2. Only a mathematician or scientist would really achieve Level 3 and experience will not normally improve the engineer's capability here. Recent graduates, for example, are the most qualified to take the Fundamentals of Engineering exam because experienced engineers have forgotten much of the technical core. The attainment expected at the undergraduate level for Outcomes 2 (Experiments) and 5 (Solve Engineering Problems) was lowered to Level 2. The Committee acknowledged the lack of realism that occurs in the classroom and only experience with interpreting data and defining real engineering problems will allow attainment of Level 3 capability. The practitioners on the committee advocated for continued level 3 attainment at the undergraduate level for Outcome 11 (Engineering tools). Exposure to a variety of modern tools can only occur at the formal education level and that in practice, those experiences will be needed to guide an engineer to choose the best tool, teach themselves to use it, and select other tools when appropriate.

There was wide agreement that Level 3 competency in Outcome 12 (Specialization) will have to be attained at the masters degree level. While Levels 1 and 2 competency are started at the undergraduate level, the Committee concluded that it would be difficult to share this responsibility, especially when a student completes specialization at the graduate level in a civil-engineering sub-discipline that was not covered at all at his or her undergraduate institution. It was understood that most schools would be accomplishing Level 1 and some Level 2 in the sub-disciplines covered in the bachelors program, but the responsibility for proof of specialization would lie with the masters program that can validate transfer credits for fundamentals.

Outcomes 3, 4, 7, and 9 competency levels did not change where experience is required to move the engineer from Level 2 to Level 3. There was much discussion on the capability of the bachelors program to attain Level 2 for Outcome 9 (Life-Long Learning). The self motivation to attain additional formal education and the requirement for self-learning on the job will occur after the undergraduate experience. While the decision was close, the Committee concluded that the bachelors programs need to do more to promote an attitude of life-long learning and Level 1 competency was too easy to accomplish.

Undergraduate competency requirement for Outcomes 6 (Professional/Ethical) and 8 (Impact of Engineering) were actually raised from Level 1 to Level 2 for similar reasons that Outcome 9 (Lifelong Learning) stayed at level 2 in the preceding paragraph. It was time to hold the bachelor's programs responsible for the knowledge, skills, and attitudes that lead to understanding professional and ethical standards and the impact of engineering on society. Competency requirements for Outcomes 10 (Contemporary Issues), 13 (Management), 14 (Business and Public Policy), and 15 (Leadership) remained at Level 1 for the bachelors program and Level 2 for experience prior to licensure. Only a large amount of post licensure experience would allow an engineer to attain Level 3 competence.

Given the new competency level definitions and revised requirements for the bachelor program, the three faculty member team re-mapped the courses against the 15 BOK Outcomes. The results of a revised USMA assessment are shown in Figure 5. Even though Outcome 12 (Specialization) is the sole responsibility of the master's level, the USMA CE program does

contribute to some level of competency in specialization, so it should be documented. Furthermore, the explicit decision to avoid splitting outcome responsibility between the bachelor and masters programs could be reversed in the future. The USMA competency attained in Outcome 1 (Technical Core) was reduced in light of the Curriculum Committee discussion. As shown in Figure 5, the revised initial assessment of the USMA program indicates a shortfall of the knowledge, skills, and attitudes for Outcome 9 (Life-Long Learning) and Outcome 14, (Business and Public Policy). The assessment for business and public policy was downgraded. The initial rating was based on averaging the assessment of business knowledge (sub-Level 1) and public policy awareness (almost Level 2). A new interpretation indicates that Level 1 ability is needed in both areas. Future curriculum revisions will require more emphasis on business practices and issues.

VIII. What's Next?

While this initial assessment is valuable and probably fairly accurate, it represents an undocumented, short-term assessment. The next step is to document the activities (homework, designs, experiments, etc.) that students actually do in these 44 courses and assess whether it is sufficient to attain a specified level of competency. Next, USMA needs to assess and document how well the students actually perform on these activities. This is not new territory as most CE programs have already been doing this in preparation for ABET accreditation visits for Outcomes 1 through 11. Existing assessment systems need to be expanded to incorporate these new outcomes 12 – 15.

While the Curriculum Committee activity progresses, the Accreditation Committee is writing and revising the commentary for these outcomes. This commentary provides guidance to civil engineering program ABET evaluators. As the specific details of the commentary changes, the degree to which a program attains the BOK outcomes may change as well. The current draft commentary (ASCE 2004b) is ambitious in what undergraduate civil engineering programs are expected to achieve. The requirements include for example, "an understanding in most of the following: biology, geology/geomorphology, engineering economics, mechanics, material properties, systems, geospatial representation, and information technology." There is an increased emphasis on ethics, leadership, social awareness, political understanding, public policy, and business practice. The outcome that requires an understanding of asset management suggests the use of tools and techniques that include "design innovations, new construction technologies, materials improvements, geo-mapping, database management, value assessment, performance models, web-based communication, and cost accounting." As program assessments become more detailed, the commentary will need to be examined carefully. In the USMA assessments, the faculty team made general judgments, but did not have to define exactly where the requisite biology, geomorphology, database management, etc. is being taught. Furthermore, as the committee work progresses and feedback from the engineering and academic communities is received, some of these requirements may be determined to be unreasonable and might be dropped. This development over time will provide a clearer picture as to what has to change in the USMA curriculum.

Because the prescribed levels of competency affect the work of multiple committees and are important to gaining acceptance and approval from accreditation agencies, a Level of

Competency Task Committee was formed to discuss and formalize commonly agreed upon definitions of these levels. The final solution will most likely be different than the level 1 through 3 competencies described in this paper. The USMA mapping and assessment may change based on these discussions.

The West Point CE assessment system is well developed and sustainable for courses taught in the Civil Engineering department. As with most schools, the process is much weaker for courses taught outside the department. As many of the new BOK outcomes require skills, knowledge and attitudes that will come from courses taught by other departments, this process needs to be improved. Furthermore, the contribution of other mandatory activities that are part of the West Point experience such as the military training, honor classes, student club activities, etc. need to be assessed in the same way as courses and the data formally collected to validate the development of knowledge, skills, and attitudes necessary for successful performance as a licensed professional engineer. Since many of the identified shortfalls will need to be corrected with changes and revisions involving the core curriculum, the civil engineering leaders need to educate and communicate with the USMA level leadership so they are not surprised by requested changes and can become part of the solution.

Much of the assessment data that gets collected is based on surveys and opinion. Such data is an administrative burden to collect. Presently the Academy goal teams are working on using embedded indicators to assist in assessment. This involves capturing data that is already inherently present in the CE program, rather than developing new data strictly for assessment purposes. This can be done for example on a Capstone design project where a specific portion of the final score on the project is allocated to identifying the social, political, and economic issues associated with the design. That portion of the final score becomes a quantitative indicator of student performance with respect to that outcome. This process becomes easier as outcomes are mapped through course objectives and even to specific lesson objectives that ultimately get directly tested on an exam, problem set, laboratory experiment, or design problem. Meyer *et.al.* (2005) illustrates an initial attempt at using embedded indicators for outcome assessment. There are many more opportunities to apply the same approach to other situations.

IX. Conclusions

The full implementation of ASCE Policy 465 that makes the masters degree the first degree of civil engineering is a monumental effort that will take two decades to implement. The process is well underway as an initial body of knowledge necessary for professional licensure has been defined in the form of 15 outcomes. The level of competency in these outcomes that is to be attained through undergraduate education, masters level education, pre-license experience, and post-license experience is being defined. The committee work involving draft commentaries, sample curricula using different types of universities, accreditation board coordination, and state licensure communication indicates that this effort will be successful.

The United States Military Academy has joined in the partnership to design a BOK compliant curriculum. The West Point civil engineering curriculum is similar enough to other undergraduate programs to make its findings relevant. It is unique enough to offer innovative solutions that may benefit other schools when addressing BOK outcomes. An initial assessment

relying on the expert opinion of three faculty members indicates that the current West Point civil engineer curriculum will allow students to attain the prescribed level of competency in most of the BOK outcomes. Given the nature of the large core curriculum and the additional activities that students are required to complete, the USMA student will exceed the required competency in areas such as leadership, communication, knowledge of contemporary issues, understanding of public policy, and professional and ethical responsibility. Shortfalls initially appear in the areas of life-long learning and business fundamentals. As the outcomes and their associated commentary are further developed, as the levels of competency are formally adopted, and as the West Point CE program conducts a more detailed assessment of its curriculum, these conclusions will likely be revised.

The USMA will be greatly affected by the implementation of Policy 465. To ensure a quality faculty, the rotating military faculty needs to attain professional licensure and their ability to do so is affected by this policy. The broad based West Point education is heavily dependent on a large core curriculum that is difficult for a single program to change. By joining in the Curriculum Committee development effort, West Point has the best opportunity to influence the changes and contribute to the solution. Early involvement in this project will also provide USMA with the maximum amount of time to react and plan for any changes that need to be made. Major changes in the BOK outcomes, the competency criteria, and the expectations of the undergraduate program have already been made in the short time that USMA has joined the effort. The West Point civil engineering program looks forward to continued involvement in helping the CE profession raise the bar.

Acknowledgments

Any opinions expressed here are those of the authors and not necessarily those of any supporting agencies.

Bibliography

ABET (2003). "Criteria for Accrediting Engineering Programs." Effective for Evaluations During the 2004-2005 Accreditation Cycle. Engineering Accreditation Commission, Accreditation Board for Engineering and Technology, Baltimore, Maryland.

ASCE (2004a). *Civil Engineering Body of Knowledge for the 21st Century*. Committee on Academic Prerequisites for Professional Practice, American Society of Civil Engineers, Reston, Virginia: ASCE.

ASCE (2004b). "Interpretation of the ABET Engineering Criteria for Civil and Similarly Named Programs", Commentary, Version 1.1, Committee on Curricula and Accreditation, American Society of Civil Engineers, Reston, Virginia

ASCE (2004c), "Model Civil Engineering Curricula Supporting the Body of Knowledge for Professional Practice" Draft Report (3 November 2004), Curriculum Committee, Committee of the Committee on Academic Prerequisites for Professional Practice, American Society of Civil Engineers, Reston, Virginia

Bloom, B.S., (ed.), Englehart, M.D., Furst, E.J., Hill, W.H., and Krathwohl, D.R. (1956) *Taxonomy of Educational Objectives: The Classification of Educational Goals. Handbook I: Cognitive Domain*. New York: David McKay

Krathwohl, D.R. (2002). "A Revision of Bloom's Taxonomy: An Overview". *Theory into Practice* 41(4), College of Education, The Ohio State University.

Meyer, K.F., Morris, M. Estes, A.C., Ressler, S.J. (2005) "How to Kill Two Birds with One Stone – Assigning Grades and Assessing Program Goals at the Same Time" 2005 ASEE Annual Conference and Exposition Proceedings, Portland, Oregon, June 12-15, 2005 (accepted).

USMA (2002). Educating Future Army Officers for a Changing World. Operational Concept for the Academic Program of the United States Military Academy, Office of the Dean, United States Military Academy, West Point, New York.

ALLEN C. ESTES
Colonel Allen C. Estes is an Associate Professor and Civil Engineering Division Director at the United States Military Academy (USMA). He is a registered Professional Engineer in Virginia. COL Estes received a B.S. degree from USMA in 1978, M.S. degrees in Structural Engineering and in Construction Management from Stanford University in 1987 and a Ph.D. degree in Civil Engineering from the University of Colorado at Boulder in 1997.

RONALD W. WELCH
Colonel Ronald W. Welch is an Associate Professor at the United States Military Academy (USMA). He is a registered Professional Engineer in Virginia. COL Welch received a BS degree in Engineering Mechanics from USMA in 1982 and MS and Ph.D. degrees in Civil Engineering from the University of Illinois at Urbana-Champaign in 1990 and 1999, respectively.

KARL (FRED) MEYER
Lieutenant Colonel Fred Meyer is an Associate Professor at the United States Military Academy (USMA). He is a registered Professional Engineer in Virginia. LTC Meyer received a B.S. degree from USMA in 1984, M.S. and Ph.D. degrees in Civil Engineering from Georgia Tech University in 1993 and 2002, respectively.

#	Body of Knowledge Outcome
1	Ability to apply knowledge of mathematics, science, and engineering
2	Ability to design and conduct experiments, as well as analyze and interpret data
3	Ability to design a system, component or process to meet desired needs
4	Ability to function on multi-disciplinary teams
5	Ability to identify, formulate, and solve engineering problems
6	Understanding of professional and ethical responsibility
7	Ability to communicate effectively
8	The broad education necessary to understand the impact of engineering solutions in a global and societal context
9	Recognition of the need for, and an ability to engage in, life-long learning
10	Knowledge of contemporary issues
11	Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice
12	Ability to apply knowledge in a specialized area related to civil engineering
13	Understanding of the elements of project management, construction, and asset management
14	Understanding of business and public policy and administration fundamentals
15	Understanding of the role of the leader and leadership principles and attitudes

Table 1. The 15 outcomes articulated in ASCE's *Civil Engineering Body of Knowledge* (ASCE 2004a)

R - Recognition
U - Understanding
A - Ability

Requirements for a Bachelor of Science in Civil Engineering (141.4 Credits)

Course Number	Course Discription	Credits	1. Mathematics, Sciences and Engineering	2. Experiements, Analysis and Interpretation	3. Ability to Design a System	4. Multi-Disciplinary Teams	5. Solve Engineering Problems	6. Professional and Ethical Responsibility	7. Communicate
EN101	Composition	3							R A U
MA103	Discrete Dynamical Systems/Intro to Calculus	4	R R R	R R R	R O R	O O R	R R R		R U O
CH101	General Chemistry I	3	R R U	R U R		R R R	R R R		R U O
IT105	Intro to Computing and Information Technology	3	R O U		O O R		R R R		R U O
HI103/7	History of the U.S./World	3						R O O	R A R
EN102	Literature	3							R U U
MA104	Calculus I	4.5	R R U	R O U	R O R	R O R	R R R		R U O
CH102	General Chemistry II	3	R R U	R U R		R R O	R R R		R A O
PL100	General Psychology	3						R O O	R U R
HI104/8	History of the U.S./World	3						R O O	R A R
PY201	Philosophy	3						R R R	R U U
MA205	Calculus II	4.5	U R U	R O U	R O R	R O R	R R R		U U O
PH201	Physics I	3.5	R O O	R U R	R O R	O R O	R R R		U U O
LX201	Foreign Language	3.5							R U R
SS201	Economics-Principles/Problems	3.5	R O R				R O O		U U O
EV203	Physical Geography	3	R O R				R O O	R R O	R U O
MA206	Probability and Statistics	3	U R U	O O U	O O R	R O R	R R R		U U O
PH202	Physics II	3.5	R R R	R U R	O O R	O R O	R R R		U U O
LX202	Foreign Language	3.5							U U R
SS202	American Politics	3.5						R O R	U A O
CE300	Fundamentals of Engineering Mechanics and Design	3	R R U	U U U	U U U	R R R	U U U		U U R
CE364	Mechanics of Materials	3.5	U U U	U U U	R U U	R U R	U U U		U A U
MA364	Engineering Mathematics	3	U U U	U O O	R O R	O O R	U U U		U U U
ME311	Thermo-Fluids Systems I	3.5	R U U	U U R	R O U	R U R	U U U		U U U
CE390	Civil Engineering Site Design	3.5	R U U		R U U	R U R	U U U	R R R	R U U
PL300	Military Leadership	3						U U R	R A O
HI301	History of the Military Art	3						U U O	U A U
CE403	Structural Analysis	3	U U A		U R O		U A A		U R U
CE371	Soil Mechanics and Foundation Engineering	3.5	U U A	A A U	U U A	R U R	U A A	O R O	U U U
CE380	Hydrology and Hydraulic Design	3.5	U U A	A U U	U U A	R U R	U A A	R R O	U U U
SS307	International Relations	3.5						U R R	A A O
EN302	Advanced Composition	3							A A A
HI302	History of the Military Art	3						U U R	A U U
CE404	Design of Steel Structures	3	A U A	R R R	U A A	U U R	A A A	R R R	U A U
CE483	Design of Reinforced Concrete Structures	3.5	A U A	A A A	U A R	R U R	A A A	O R O	U A U
CEXXX	Field Elective (Advanced Structural Analysis)	3	A U A	O O R	U O U		A A A		U U U
CEXXX	Field Elective (Wood and Masonry Design)	3	A U A	A A A	U A A	R U R	A A A	O R O	U U U
LW403	Constitutional/Military Law	3.5						U U U	U U U
ME306	Dynamics	3	U U U		R O U		A U A		U U U
CE492	Design Structural Systems	3	A A A		A A A	U A A	A A A	U A R	A A U
CEXXX	Engineering Elective (Vibrations/Independent Study)	3	O O A	U O U	U U A	R U R	A A A		U A U
CE460	Construction Management	3		U U O		U U O	U U A	U U A	U U A
EE301	Fundamentals of Electrical Engineering	3.5	U U U	U U U	U O R	R O R	U U U		U U R
CE400	Civil Engineering Professional Practice	1				U U U		U U U	U A R
	Honor Instruction							R U U	R R O
	VETclasses							U U U	R R O
	Beast Barracks			R O O		R R U		O R O	R U R
	Buckner			R O O		U U U		O R O	R U U
	CTLT					U U U		U A U	U A A
	MIAD							O R O	R R A
	Cadre Detail (Beast/Buckner)					U U U		U A U	U A A
	Physical Education courses								O R O

Table 2. Initial USMA Assessment of BOK Competency Levels Attained in the Courses and Activities in the West Point Civil Engineering Curriculum. The Results are the Independent Assessments of Three Senior Faculty Members where the Ratings are: O- None; R-Recognition, U-Understanding, A-Ability

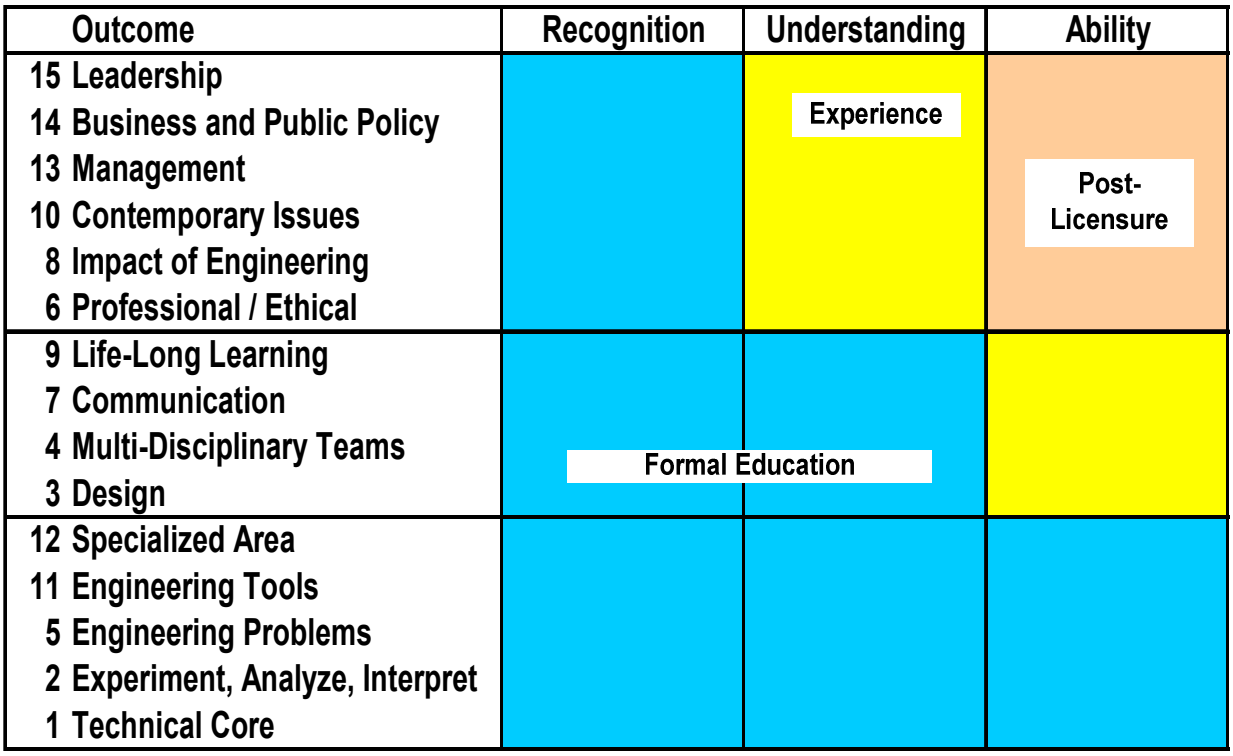

Figure 1. The Expected Competency Levels for BOK Outcomes Attained Through Formal Education, Experience Prior to Obtaining Professional Registration, and Post-Licensure Experience.

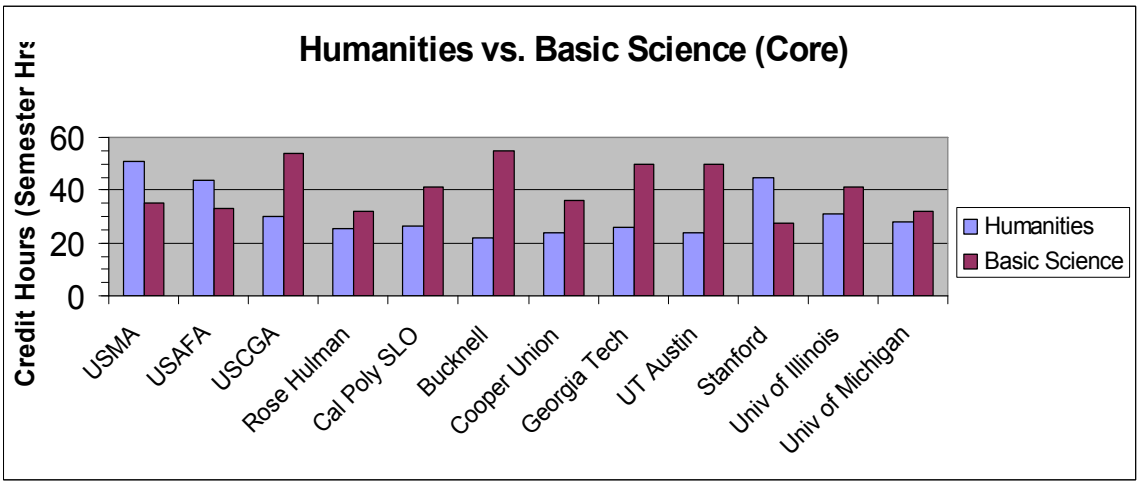

Figure 2. A comparison of the number of semester credit hours in the humanities and basic math/science areas required at the United States Military Academy relative to other prominent civil engineering programs

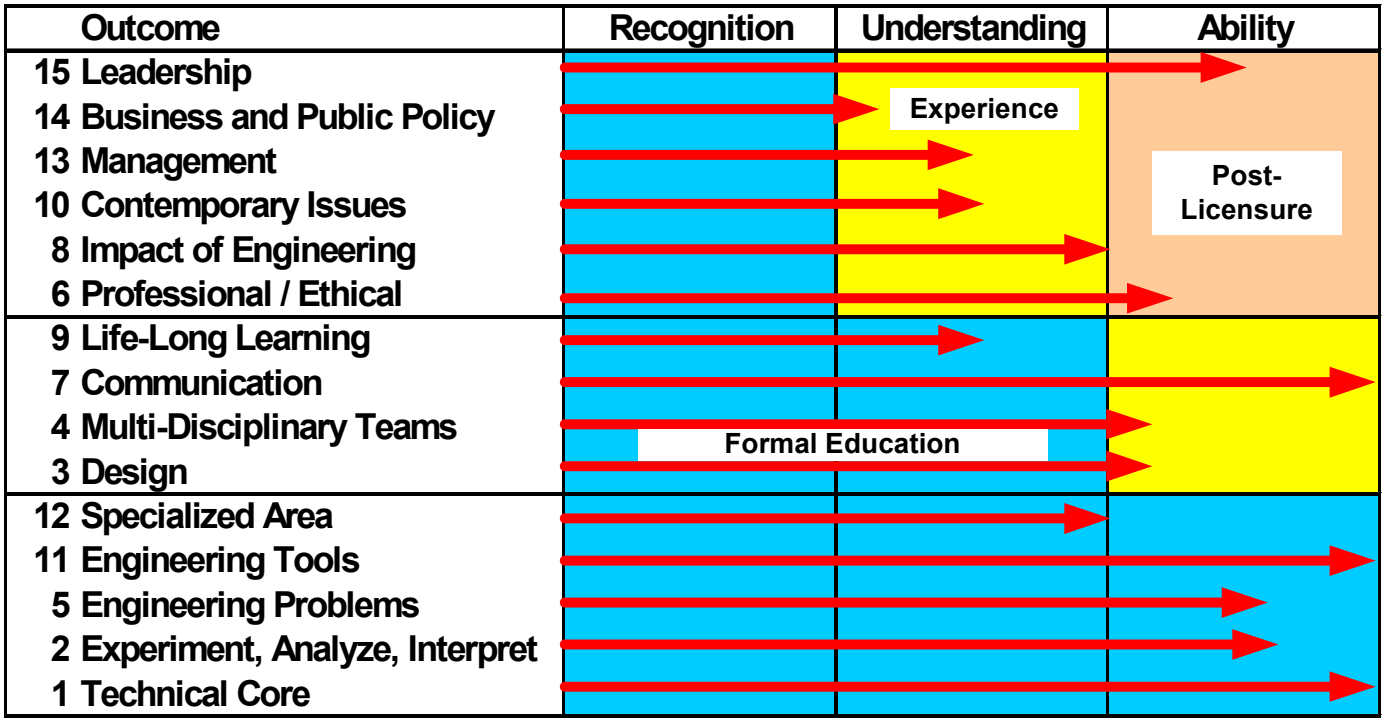

Figure 3. Initial Assessment of Competency Attained in each of the BOK Outcomes Through Completion the Four Year West Point Curriculum

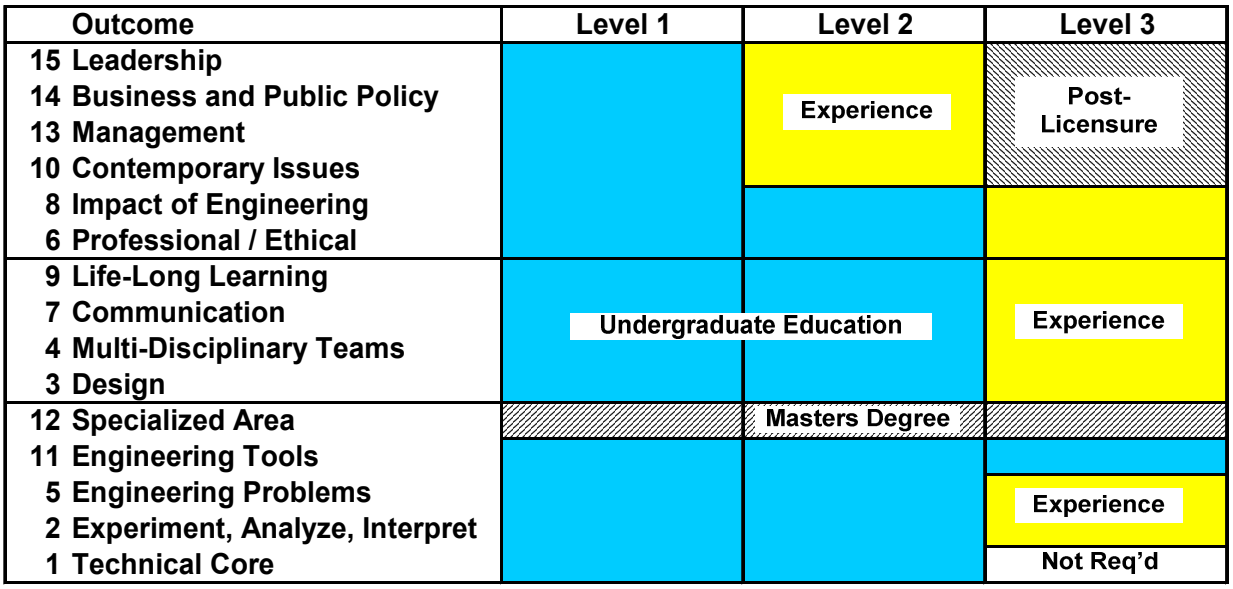

Figure 4: Proposed Curriculum Committee Revisions to the Competency Level Designations and the Respective Responsibilities of Formal Education and Experience in Attaining these Levels in the BOK Outcomes

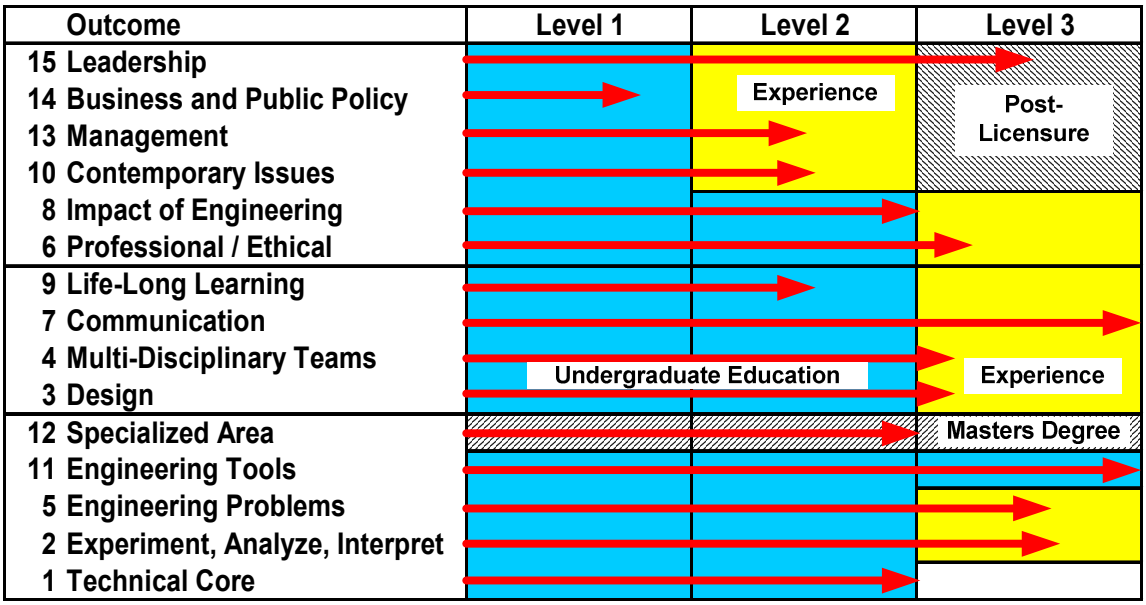

Figure 5. Revised Assessment of Competency Attained in USMA Curriculum as a Result of Curriculum Committee Discussions