The Engineering Competency Model

ABSTRACT:

An Engineering Competency Model has been developed to serve as a guide for the development of professionals in the engineering workforce. The Engineering Competency Model ("the model") provides a career ladder/lattice for the engineering profession and promotes an understanding of the skill sets and competencies that are essential to educate and train a globally competitive engineering workforce. This competency model for engineering will serve as a resource to inform discussions among industry leaders, educators, economic developers, and public workforce investment professionals as they collaborate to identify specific employer skill needs, develop competency-based curricula and training models, and develop industry-defined performance indicators, skill standards, and certifications.

The creation of the Engineering Competency Model included an examination of existing bodies of knowledge, as well as the inclusion and involvement of the stakeholders within the engineering community, including associations, industry and academia. As a part of this effort, work is also being done to provide materials for faculty, guidance counselors, and others who work with individuals who are entering the STEM pipeline to provide specific guidance on the core competencies and skills necessary, as well as those that an individual will need to maintain proficiency during their career.

The need for qualified engineers is expected to increase over the next seven years, with the engineering field expected to grow by 8.6% between 2012 and 2022. The result will be over 544,000 job openings due to growth and net replacements during that period.   It is imperative that clear and specific guidance is given to those individuals who may be suited to fill this need and will enter into the STEM pipeline. This session will highlight the new materials which can be used by individuals, faculty, etc. to understand the core competencies and skills, as well as to provide a brief overview of the Engineering Competency Model creation.

PAPER:

A working partnership of several engineering societies and a department of the federal government, the Team, has come together to develop and release the Engineering Competency Model ("the model").

The Team identified the development of an engineering competency model as a key priority to help educators, employers, professionals and future engineers understand the knowledge and skills needed to thrive in the workplace. Funded by a generous grant from the United Engineering Foundation, the Team built the model to provide a universal template for the knowledge, skills and abilities necessary not only for entering the engineering profession but also for maintaining competency and proficiency

> *"The Engineering Competency Model has the potential to unite the profession on the fundamental requirements that engineers will need to solve the global challenges we are facing."*

during one's career.   The Engineering Competency Model is tied to lifelong learning and the individual tiers do not designate specific academic degrees.

A Framework for the Engineering Profession:

The Engineering Competency Model is designed to establish a more consistent guideline for the engineering profession. The model is intended for use by

- *Industry leaders, employers and human resource professionals*, to identify skill needs and assess competencies and performance
- *Educators/academics*, to inform the development of competency-based curricula and training
- *Workforce professionals and career counselors,* to develop resources for career exploration and guidance
- *Current and future engineers,* to gain a clear understanding of the skills and abilities necessary to enter, advance and succeed in the industry

The specific guidelines offered in the Engineering Competency Model were designed to assist in the understanding of the core set of abilities needed to enter the engineering profession, in general, and to assist employees in maintaining their skills and be successful throughout their careers.

At its core, the Engineering Competency Model is a four-tier graphical model that uses a pyramid to depict the required key competencies. Tiers one through four (the bottom four tiers) include personal, academic, workplace and technical competencies that are common to the engineering profession. In the future, there will be an opportunity to adopt the model and apply a fifth tier to include discipline-specific competencies. Tier six, the final optional tier, will be divided into two areas: competencies needed for management and occupation-specific requirements for a particular position within the engineering profession. The graphic also lists the different competencies within each tier.   (The full Engineering Competency Model is attached to better show the graphical tiers as well as an explanation of each competency.)
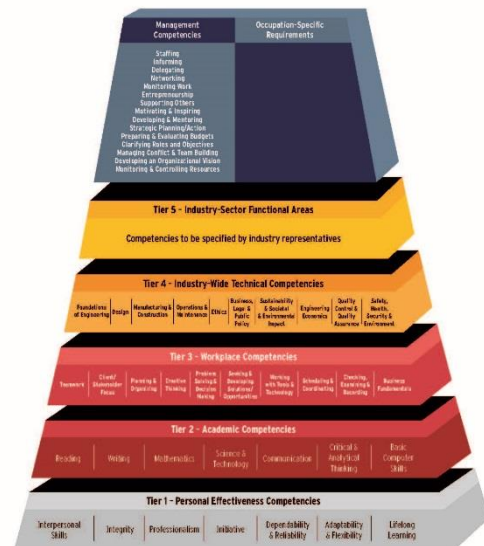
As an example, if a future engineer wished to understand what could be expected of their critical and analytical thinking skills in their future workplace, they could utilize Tier 2, Section 2.6 of the Engineering Competency Model. In this section, the future engineer would understand the expectations of the desired reasoning and mental agility skills needed and could identify future

coursework to obtain those skills to ensure a smooth transition from an academic environment into the future work place. Likewise, educators can use the model to identify gaps in a future engineers training and create a tailored education program to address those gaps.

Engineering Competency Model Development Process:

To begin development of the model, the Team assigned a dedicated research working group to oversee the project, and recruited subject matter experts to review the vast amount of background information, including ABET accreditation criteria, bodies of knowledge from various engineering societies, the Project Lead the Way outline, and curricula and related resources from academic institutions around the country. The working group also identified subject matter experts from amongst its own organizations, representing industry and academia, to assist the research team in developing and critiquing the draft model through a series of webinars designed to gather feedback and further refine the draft.

Throughout the development of the Engineering Competency Model, the working group sought to gather feedback and input from stakeholders across the engineering community, from educators of future engineers to those who employ engineers. A webinar was held in February, 2015 for engineering societies and other stakeholders to explain the development process, discuss how the model could be a useful tool for engineering-related societies in the future, and get feedback on the preliminary draft. The working group also distributed a survey to solicit feedback from the engineering community and gathered input from over 100 engineering leaders, which was used to inform updates and revisions to the model.

In April, 2015, the working group held a Validator's Meeting with the subject matter experts, representatives from engineering societies, and other members of the engineering community to gather additional insight and finalize the Engineering Competency Model. Additionally, the model is currently being endorsed by those engineering societies. The Engineering Competency Model is attached.

Moving Forward:

With the need for qualified engineers expected to increase over the next seven years, the engineering field is expected to grow by 8.6% between 2012 and 2022. The result will be over 544,000 job openings due to growth and net replacements during that period. It is imperative that clear and specific guidance is given to those individuals who may be suited to fill this need and will enter into the STEM pipeline.

Promotion and continued work on the Engineering Competency Model is a crucial activity, as it has the potential to provide future practitioners with the knowledge of the competencies that will be necessary for this global engineer of the future.

This session will highlight the new materials which can be used by individuals, faculty, etc. to understand the core competencies and skills, as well as to provide a brief overview of the Engineering Competency Model creation.
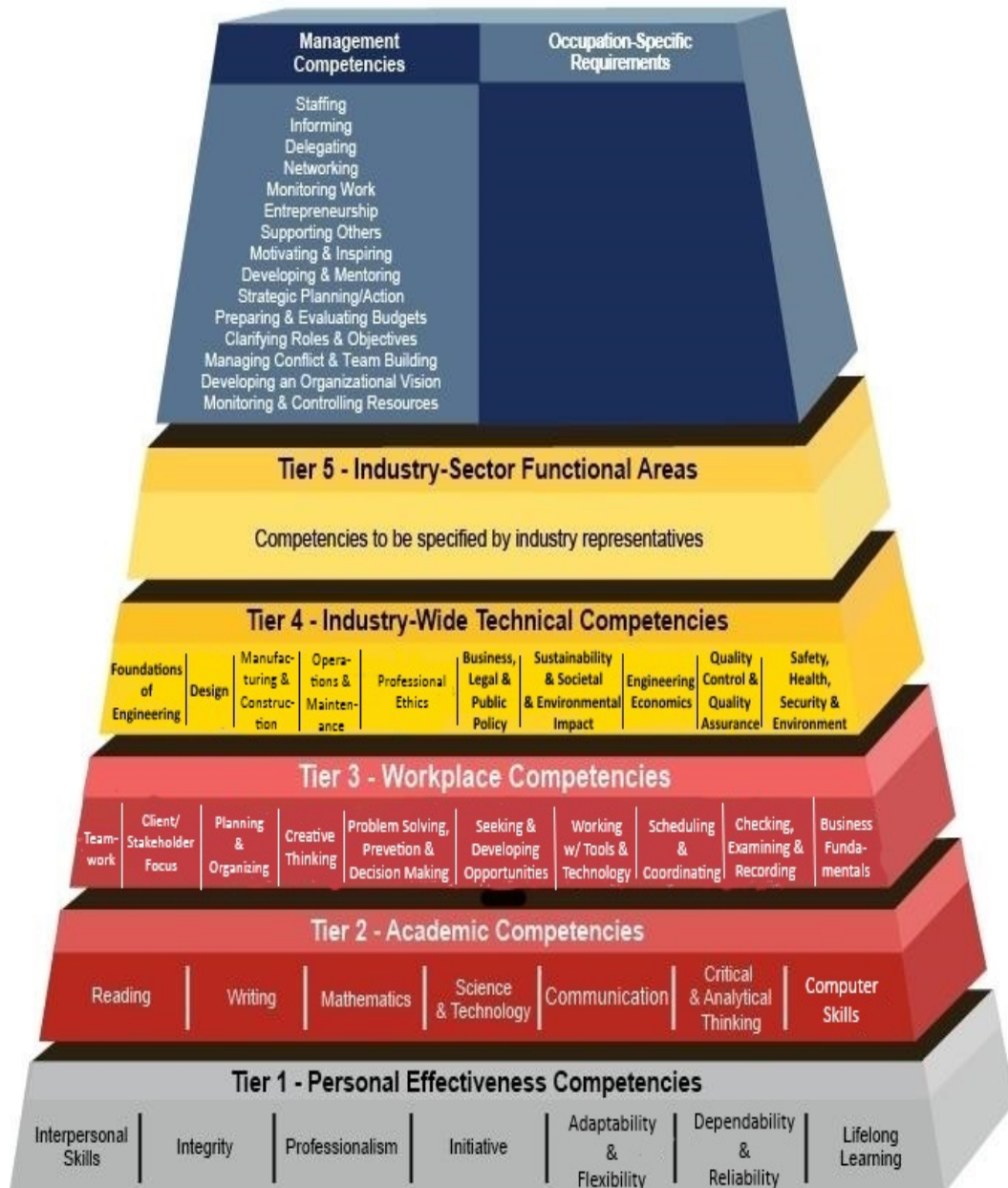
Engineering Competency Model

May 2015

Tier 5 - Industry-Sector Functional Areas

Competencies to be specified by industry representatives

Management Competencies
- Staffing
- Informing
- Delegating
- Networking
- Monitoring Work
- Entrepreneurship
- Supporting Others
- Motivating & Inspiring
- Developing & Mentoring
- Strategic Planning/Action
- Preparing & Evaluating Budgets
- Clarifying Roles & Objectives
- Managing Conflict & Team Building
- Developing an Organizational Vision
- Monitoring & Controlling Resources

Occupation-Specific Requirements

Tier 4 - Industry-Wide Technical Competencies
Foundations of Engineering | Design | Manufacturing & Construction | Operations & Maintenance | Professional Ethics | Business, Legal & Public Policy | Sustainability & Societal & Environmental Impact | Engineering Economics | Quality Control & Quality Assurance | Safety, Health, Security & Environment

Tier 3 - Workplace Competencies
Teamwork | Client/ Stakeholder Focus | Planning & Organizing | Creative Thinking | Problem Solving, Prevetion & Decision Making | Seeking & Developing Opportunities | Working w/ Tools & Technology | Scheduling & Coordinating | Checking, Examining & Recording | Business Fundamentals

Tier 2 - Academic Competencies
Reading | Writing | Mathematics | Science & Technology | Communication | Critical & Analytical Thinking | Computer Skills

Tier 1 - Personal Effectiveness Competencies
Interpersonal Skills | Integrity | Professionalism | Initiative | Adaptability & Flexibility | Dependability & Reliability | Lifelong Learning

Table of Contents

Employment and Training Administration
United States Department of Labor
www.doleta.gov
Engineering Competency Model – May 2015   2

About the Model

The Engineering Competency Model identifies the knowledge, skills, and abilities needed for workers to perform successfully in the field of engineering.

The model is depicted as a pyramid consisting of several tiers. The arrangement of the tiers in this shape is not meant to be hierarchical, or to imply that competencies at the top are at a higher level of skill. Instead, the model's tapered shape represents the increasing specialization and specificity of proficiencies covered. Its tiers are further divided into blocks that represent competency areas (i.e., groups of knowledge, skills, and abilities), which are defined using critical work functions and technical content areas.

Foundational Competencies

Tiers 1 through 3 represent the "soft skills" and work readiness skills that most employers demand. Each tier covers a different group of competencies:

Tier 1 – Personal Effectiveness Competencies are personal attributes essential for all life roles. Often referred to as "soft skills," personal effectiveness competencies are generally learned in the home or community and honed at school and in the workplace.

> **Competency** – A cluster of related knowledge, skills, and abilities that affects a major part of one's job (a role or responsibility), that correlates with performance on the job, that can be measured against well-accepted standards, and that can be improved through training, development, and experience.

Tier 2 – Academic Competencies are primarily learned in a school setting. They include cognitive functions and thinking styles. Academic competencies are likely to apply to all industries and occupations.

Tier 3 – Workplace Competencies represent motives and traits, as well as interpersonal and self-management styles. They are generally applicable to a large number of occupations and industries.

Industry-specific Competencies

Tiers 4 and 5 show the industry-wide technical competencies needed to create career lattices within an industry. These competencies are considered cross-cutting, as they allow a worker to move easily across industry sub-sectors. Rather than narrowly following a single occupational career ladder, this model supports the development of an agile workforce. Like the foundational tiers, Tiers 4 and 5 deal with distinct types of competencies:

Tier 4 – Industry-Wide Competencies cover the knowledge and skills and abilities from which workers across the industry can benefit, regardless of the sector in which they operate. Because of this, many of the critical work functions on this tier deal with awareness or understanding.

Tier 5 – Industry-Sector Competencies represent a sub-set of industry-wide competencies that are specific to an industry sector. As a result, the critical work functions deal more with performing tasks than those on Tier 4. The Employment and Training Administration's Engineering model does not include Tier 5 competencies.

Using the Model

While it attempts to cover a wide range of industry competencies, the model is not intended to be a definitive list of all engineering knowledge, skills, and abilities; nor is it intended that all workers in the field possess all competencies listed. The Engineering Competency Model is instead intended as a resource for further explorations of the competencies needed in this critical field. Users of the model are encouraged to add or subtract competencies as they see fit, as well as expand the scope of the model to include a specific sector or occupation. For examples of how the model can be used, please visit the Competency Model Clearinghouse (http://www.careeronestop.org/competencymodel/). The Clearinghouse also includes the Build a Model Tool, which can be used to edit an existing model or create a new one.

The U.S. Department of Labor's Employment and Training Administration (ETA) is committed to promoting reasonable testing and job accommodations for candidates with documented disabilities or health-related needs, as recognized under the Americans with Disabilities Act (ADA) Amendments Act of 2008. For organizations that conduct any testing or assessments based on identification of competencies, we recommend that they treat every request for accommodations on a case-by-case basis and that they have established policies and procedures giving people with disabilities or health-related needs equitable access to jobs in the industries represented here. Using appropriate accommodations or adaptive devices will ensure that individuals with disabilities can meet the objective of specific competencies. For more information on job accommodations, please visit the Job Accommodation Network: http://www.askjan.org. For additional guidance on testing and assessment administration and accommodations, please see *Testing and Assessment: A Guide to Good Practices for Workforce Investment Professionals* http://www.onetcenter.org/dl_files/proTestAsse.pdf.

Tier 1 – Personal Effectiveness Competencies

1.1 Interpersonal Skills: Displaying skills to work effectively with others from diverse backgrounds.

1.1.1   Demonstrating sensitivity/empathy

    1.1.1.1   Show sincere interest in others and their concerns.
    1.1.1.2   Demonstrate sensitivity to the needs and feelings of others.
    1.1.1.3   Look for ways to help people and deliver assistance.

1.1.2   Demonstrating insight into behavior

    1.1.2.1   Recognize and accurately interpret the communications of others as expressed through various formats (e.g., writing, speech, American Sign Language, computers, etc.).
    1.1.2.2   Recognize when relationships with others are strained.
    1.1.2.3   Show understanding of other's behaviors and motives by demonstrating appropriate responses.
    1.1.2.4   Demonstrate flexibility for change based on the ideas and actions of others.
    1.1.2.5   Understand the impact of unconscious bias.

1.1.3   Maintaining open relationships

    1.1.3.1   Maintain open lines of communication with others.
    1.1.3.2   Encourage others to share problems and successes.
    1.1.3.3   Establish a high degree of trust and credibility with others.

1.1.4   Showing Cultural Awareness

    1.1.4.1   Demonstrate respect for coworkers, colleagues, and clients.
    1.1.4.2   Interact respectfully and cooperatively with others who are of a different race, religion, nationality, ethnicity, culture, or age, or have different abilities, gender, sexual orientation, linguistics, or marital or family status.
    1.1.4.3   Demonstrate sensitivity, flexibility, open-mindedness, and inclusivity when dealing with different values, beliefs, perspectives, customs, or opinions.
    1.1.4.4   Value an environment that supports and accommodates a diversity of people and ideas.

1.2 Integrity: Displaying strong moral principles and work ethic

1.2.1   Taking responsibility and being accountable

    1.2.1.1   Accept responsibility and accountability for one's decisions and actions and for those of one's group, team, or department.
    1.2.1.2   Demonstrate global, social, intellectual, and technological responsibility.

1.2.2   Behaving ethically

    1.2.2.1   Encourage others to behave ethically.
    1.2.2.2   Understand that behaving ethically goes beyond what the law requires.
    1.2.2.3   Respect the need for confidentiality, when appropriate.

1.2.3   Acting fairly

1.2.3.1	Treat others with honesty, fairness, and respect.
1.2.3.2	Make decisions that are objective and reflect the just treatment of others.

1.2.4   Taking responsibility

1.2.4.1	Take responsibility for accomplishing work goals within accepted timeframes.
1.2.4.2	Accept responsibility for one's decisions and actions and for those of one's group, team, or department.

1.3 Professionalism: Maintaining a professional presence.

1.3.1   Demonstrating emotional intelligence

1.3.1.1	Maintain composure and keep emotions in check.
1.3.1.2	Deal calmly and effectively with stressful or difficult situations.
1.3.1.3	Accept criticism tactfully and attempt to learn from it.

1.3.2   Professional appearance

1.3.2.1	Maintain a professional demeanor.
1.3.2.2	Dress appropriately for occupational and worksite requirements.
1.3.2.3	Maintain appropriate personal hygiene.

1.3.3   Maintaining a positive attitude

1.3.3.1	Project a positive image of oneself and the organization.
1.3.3.2	Demonstrate attitudes supportive of professional work such as commitment, curiosity, entrepreneurship, and optimism.
1.3.3.3	Take pride in one's work and the work of the organization.

1.3.4   Showing good judgment

1.3.4.1	Demonstrate good personal and professional judgment.

1.4 Initiative: Demonstrating a commitment to effective job performance by taking action on one's own and following through to get the job done.

1.4.1   Persisting

1.4.1.1	Pursue work with drive and a strong accomplishment orientation.
1.4.1.2	Persist to accomplish a task despite difficult conditions, tight deadlines, or obstacles and setbacks.

1.4.2   Taking initiative

1.4.2.1	Go beyond the routine demands of the job to increase its variety and scope.
1.4.2.2	Provide suggestions and/or take actions that result in improved work processes, communications, or task performance.
1.4.2.3	Take initiative to seek out new work challenges, influence events, or originate action.

1.4.3   Setting challenging goals and taking risks

1.4.3.1   Establish and maintain personally challenging but realistic work goals.
1.4.3.2   Exert effort toward task mastery.
1.4.3.3   Bring issues to closure by pushing forward until a resolution is achieved.
1.4.3.4   Demonstrate a willingness to take calculated risks.

1.4.4   Working independently

1.4.4.1   Develop own ways of working effectively and efficiently.
1.4.4.2   Perform effectively even with minimal direction, support, or approval.

1.4.5   Achievement motivation

1.4.5.1   Strive to exceed standards and expectations.
1.4.5.2   Exhibit confidence in capabilities and an expectation to succeed in future activities.

1.5 Adaptability and Flexibility: Displaying the capability to adapt to new, different, or changing requirements.

1.5.1   Entertaining new ideas

1.5.1.1   Is open to considering new ways of doing things.
1.5.1.2   Actively seek out and carefully consider the merits of new approaches to work.
1.5.1.3   Embrace new approaches when appropriate and discard approaches that are no longer working.

1.5.2   Dealing with ambiguity, complexity, and rapid change

1.5.2.1   Take proper and effective action when necessary without having all the essential facts in hand.
1.5.2.2   Easily adapt plans, goals, actions, or priorities in response to unpredictable or unexpected events, pressures, situations, and job demands.
1.5.2.3   Effortlessly shift gears and change direction in the face of rapid change or when working on multiple projects or issues.

1.6 Dependability and Reliability: Displaying responsible behaviors at work.

1.6.1   Fulfilling obligations
1.6.1.1   Behave consistently and predictably.
1.6.1.2   Is reliable, responsible, and dependable in fulfilling obligations.
1.6.1.3   Diligently follow through on commitments and consistently complete assignments by deadlines.

1.6.2   Attendance and punctuality
1.6.2.1   Come to work on time and as scheduled.
1.6.2.2   Arrive on time for meetings or appointments.
1.6.2.3   Be punctual when dialing in to phone calls and web conferences.

1.6.3   Attending to details
1.6.3.1   Diligently check work to ensure that all essential details have been considered.

| 1.6.3.2 | Notice errors or inconsistencies and take prompt, thorough action to correct them. |

1.6.4 Following directions

1.6.4.1	Follow directions as communicated in a variety of ways such as writing, speech, American Sign Language, computers or other formats.
1.6.4.2	Comply with organizational rules, policies, and procedures.
1.6.4.3	Ask appropriate questions to clarify any instructional ambiguities.

1.7 Lifelong Learning: Demonstrating curiosity and a persistent desire for continuous learning.

1.7.1 Demonstrating an interest in learning

1.7.1.1	Take actions showing an interest in personal and professional lifelong learning and development.
1.7.1.2	Seek feedback from multiple sources about how to improve and develop.
1.7.1.3	Perform a self-evaluation to recognize preferences, strengths, and weaknesses.
1.7.1.4	Modify behavior based on feedback or self-analysis of past mistakes.
1.7.1.5	Learn and accept help from supervisors and co-workers.

1.7.2 Participating in learning activities

1.7.2.1	Identify when it is necessary to acquire new knowledge and skills.
1.7.2.2	Take steps to develop and maintain knowledge, skills, and expertise necessary to perform one's role successfully by participating in relevant training and professional development programs.
1.7.2.3	Actively pursue opportunities to broaden and deepen knowledge and skills through seminars, conferences, professional groups, reading publications, job shadowing, and/or continuing education.

1.7.3 Using change as a learning opportunity

| 1.7.3.1 | Anticipate changes in work demands and searches for and participates in assignments or training that address these changing demands. |
| 1.7.3.2 | Treat unexpected circumstances as opportunities to learn. |

1.7.4 Identifying career interests

1.7.4.1	Take charge of personal career development by identifying occupational interests, strengths, options, and opportunities.
1.7.4.2	Make insightful career planning decisions that integrates others' feedback.
1.7.4.3	Choose topics most appropriate for continuing education to increase depth of technical and non-technical knowledge pertinent to the specific area of engineering practice.
1.7.4.4	Identify means by which engineers can continue to learn throughout their careers.

1.7.5   Integrating and applying learning

    1.7.5.1   Integrate newly learned knowledge and skills with existing knowledge and skills.

    1.7.5.2   Use newly learned knowledge and skills to complete tasks, particularly in new or unfamiliar situations.

    1.7.5.3   Formulate a lifelong learning plan, monitor and update it as needed, and execute the first steps in the plan.

    1.7.5.4   Show a self-awareness of how one learns (i.e., metacognition).

Tier 2 – Academic Competencies

2.1 Reading: Understanding written sentences, paragraphs, and figures in work-related documents on paper, on computers, or adaptive devices.

2.1.1 Comprehension

2.1.1.1 Locate and understand written information in prose and in documents such as manuals, reports, memos, letters, forms, graphs, charts, tables, calendars, schedules, signs, notices, applications, contracts, regulations, and directions.
2.1.1.2 Understand the purpose of written materials.
2.1.1.3 Comprehend the author's meaning and identify the main ideas expressed in the written material.

2.1.2 Attention to detail

2.1.2.1 Note details and facts.
2.1.2.2 Detect inconsistencies.
2.1.2.3 Identify implied meaning and details.
2.1.2.4 Recognize missing information.

2.1.3 Information analysis

2.1.3.1 Critically evaluate and analyze information in written materials.
2.1.3.2 Review written information for completeness and relevance.
2.1.3.3 Distinguish fact from opinion.
2.1.3.4 Identify trends.
2.1.3.5 Synthesize information from multiple written materials.

2.1.4 Information integration

2.1.4.1 Integrate what is learned from written materials with prior knowledge.
2.1.4.2 Use what is learned from written material to follow instructions and complete tasks.
2.1.4.3 Apply what is learned from written material to new situations.

2.2 Writing: Using standard business English to compile information and prepare written documents on paper, computers, or adaptive devices.

2.2.1 Organization and development

2.2.1.1 Create documents such as letters, directions, manuals, reports, graphs, spreadsheets, and flow charts.
2.2.1.2 Communicate thoughts, ideas, information, messages and other written information, which may contain technical material, in a logical, organized, and coherent manner.
2.2.1.3 Present well-developed ideas supported by information and examples.
2.2.1.4 Proofread finished documents for errors.
2.2.1.5 Tailor content to appropriate audience and purpose.
2.2.1.6 Distribute written materials appropriately for intended audiences and purposes.

2.2.2 Mechanics

    2.2.2.1   Use standard syntax and sentence structure.
    2.2.2.2   Use correct spelling, punctuation, and capitalization.
    2.2.2.3   Use correct grammar (e.g., correct tense, subject-verb agreement, no missing words).
    2.2.2.4   Write legibly when using handwriting to communicate.

2.2.3 Tone

    2.2.3.1   Use language appropriate for the target audience.
    2.2.3.2   Use a tone and word choice appropriate for the industry and organization (e.g., writing is professional and courteous).
    2.2.3.3   Show insight, perception, and depth in writing.

2.3 Mathematics: Using mathematics to express ideas and solve problems.

2.3.1 Computation
    2.3.1.1   Add, subtract, multiply, and divide with whole numbers, fractions, decimals, and percents.
    2.3.1.2   Calculate averages, ratios, proportions, and rates.
    2.3.1.3   Convert decimals to fractions and fractions to decimals.
    2.3.1.4   Convert fractions to percents and percents to fractions.
    2.3.1.5   Convert decimals to percents and percents to decimals.
    2.3.1.6   Understand relationships between numbers and identify and understand patterns.
    2.3.1.7   Apply arithmetic operations on numbers, percentages, square root, exponentiation, and logarithmic functions.

2.3.2 Measurement and estimation
    2.3.2.1   Take measurements of time, temperature, distances, length, width, height, perimeter, area, volume, weight, mass, velocity, and speed.

    2.3.2.2   Use and report measurements correctly.

    2.3.2.3   Correctly convert from one measurement or unit to another (e.g., from English to metric or International System of Units (SI), or Fahrenheit to Celsius).

2.3.3 Application
    2.3.3.1   Understand number systems and relationships (e.g., whole numbers, decimals, fractions, alternate base systems).

    2.3.3.2   Understand plane and solid geometry (e.g., distance, perimeter, area, volume, spatial coordinates, visualization, spatial reasoning, and geometric modeling).

    2.3.3.3   Use appropriate mathematical formulas and techniques to solve problems.

    2.3.3.4   Translate practical problems into useful mathematical expressions.

    2.3.3.5   Apply algebra, trigonometry, probability and statistics, differential and integral calculus, and multivariate calculus to solve engineering problems.

Employment and Training Administration
United States Department of Labor
www.doleta.gov
Engineering Competency Model – May 2015   12

2.3.3.6	Apply an appropriate area of mathematics in the planning or design of a facility, structure, system, or product or a portion of a facility, structure, system or product.
2.3.3.7	Organize and analyze a data set to determine its statistical variability and to conduct hypothesis testing.
2.3.3.8	Apply differential equations to characterize time-dependent physical processes.
2.3.3.9	Use the language of mathematics to express mathematical ideas.
2.3.3.10	Use inductive and deductive reasoning, conjectures, arguments, strategies, and interpretation of results.

2.4 Science and Technology: Using scientific rules and methods to express ideas and solve problems on paper, on computers, or on adaptive devices.

2.4.1 Comprehension

2.4.1.1	Understand basic scientific principles and use appropriate technology.
2.4.1.2	Understand the scientific method (i.e., identify problems, collect information, form opinions and draw conclusions).
2.4.1.3	Understand overall intent and proper procedures for set-up and operation of equipment.
2.4.1.4	Explain key concepts of the scientific method and other inquiry and problem-solving processes.

2.4.2 Application

2.4.2.1	Understand the applicability and various types of modeling and experimentation.
2.4.2.2	Apply basic scientific principles and technology to complete tasks.
2.4.2.3	Conduct experiments and analyze and interpret the results.
2.4.2.4	Understand the composition, structure, properties, and reactions of matter, especially of atomic and molecular systems.
2.4.2.5	Understand physics – matter and energy and physical interactions.

2.5 Communication: Listening, speaking, and signaling so others can understand using a variety of methods, including hearing, speech, American Sign Language, instant messaging, text-to-speech devices, etc.

2.5.1 Communicating

2.5.1.1	Express relevant information appropriately to individuals or groups taking into account the audience and the nature of the information (e.g., technical or controversial).
2.5.1.2	Convey information clearly, correctly, and succinctly.
2.5.1.3	Use common English conventions including proper grammar, tone, and pace.
2.5.1.4	Effectively establish interpersonal contact with one or more individuals using eye contact, body language and non-verbal expression as appropriate to the person's culture.

| 2.5.1.5 | Explain the technical aspects and benefits of an engineering project to nontechnical audiences. |
| 2.5.1.6 | Plan, prepare, and deliver an oral presentation with appropriate visual aids, handouts, and/or other support materials. |

2.5.2   Receiving information

2.5.2.1	Attend to, understand, interpret, and respond to messages received in a variety of ways, including hearing, American Sign Language, instant messaging, text-to-speech devices, and other methods.
2.5.2.2	Identify feelings and concerns communicated in various formats, such as writing, speech, American Sign Language, computers, etc. and respond appropriately.
2.5.2.3	Comprehend complex instructions.
2.5.2.4	Consider others' viewpoints and alter opinion when it is appropriate to do so.
2.5.2.5	Apply active interpersonal communication skills using reflection, restatement, questioning, and clarification.
2.5.2.6	Effectively answer questions of others or communicate an inability to do so and suggest other sources of answers.

2.5.3   Observing carefully

2.5.3.1	Notice nonverbal cues and respond appropriately.
2.5.3.2	Attend to visual sources of information (e.g., video).
2.5.3.3	Ascertain relevant visual information and use appropriately.

2.5.4   Persuasion/influence

2.5.4.1	Influence others.
2.5.4.2	Persuasively present thoughts and ideas.
2.5.4.3	Gain commitment and ensure support for proposed ideas.

2.6 Critical and Analytical Thinking: Using logical thought processes to analyze information and draw conclusions.

2.6.1   Reasoning

2.6.1.1	Possess sufficient inductive and deductive reasoning ability to perform job successfully.
2.6.1.2	Critically review, analyze, synthesize, compare, and interpret information.
2.6.1.3	Draw conclusions from relevant and/or missing information.
2.6.1.4	Understand the principles underlying the relationship among facts and apply this understanding when solving problems.
2.6.1.5	Use logic and reasoning to identify strengths and weaknesses of alternative solutions or approaches to a problem.

2.6.2   Mental agility

| 2.6.2.1 | Identify connections between issues. |
| 2.6.2.2 | Quickly understand, orient to, and integrate new information. |

2.7 Computer Skills: Using information technology and related applications, including adaptive devices and software, to convey and retrieve information.

2.7.1   Digital literacy

2.7.1.1   Understand the basic functions and terminology related to computer hardware, software, information systems, and communication devices.

2.7.1.2   Use basic computer software, hardware, and communication devices to perform tasks.

2.7.2   Using software

2.7.2.1   Use word processing software to compose, organize, edit, and print documents and other business communications.

2.7.2.2   Use spreadsheet software to enter, manipulate, edit, and format text and numerical data.

2.7.2.3   Use presentation software to create, manipulate, edit, and present digital representations of information to an audience.

2.7.2.4   Use database software to manage data.

2.7.2.5   Use system modeling software to diagnose problems and explore possible solutions.

2.7.2.6   Create and manipulate pictures in graphics programs or other applications.

2.7.2.7   Create and maintain a well-organized electronic file storage system.

2.7.3   Using the Internet and email

2.7.3.1   Use the Internet to search for online information and interact with Web sites.

2.7.3.2   Use the Internet and web-based tools to manage basic workplace tasks (e.g., calendar management, contacts management, and timekeeping).

2.7.3.3   Use email to communicate in the workplace.

2.7.3.4   Understand the different types of social media and their appropriate workplace and non-workplace uses, and the impact that various social media activities can have on one's personal and professional life.

2.7.3.5   Employ collaborative/groupware applications to facilitate group work.

2.7.4   Ensuring computer security

2.7.4.1   Understand and comply with the organization's privacy policy and information security guidelines.

2.7.4.2   Defend against potential abuses of private information.

2.7.4.3   Recognize and respond appropriately to suspicious vulnerabilities and threats.

2.7.4.4   Handle removable media with care, recognizing it as a potential source of malware.

2.7.4.5   Use the most recent security software, web browser, and operating system to protect against online threats.

2.7.4.6   Utilize strong passwords, passphrases, and basic encryption.

2.7.4.7   Recognize secure Web addresses.

2.7.4.8   Ensure backups exist for important files and information, so that they can be restored in the event of corruption by malware or otherwise.

Tier 3 – Workplace Competencies

3.1 Teamwork: Working cooperatively with others to complete work assignments.

3.1.1   Identifying team membership and role

3.1.1.1   Serve as a leader or a follower, depending on what is needed to achieve the team's goals and objectives.
3.1.1.2   Identify and draw upon team members' strengths and weaknesses to achieve results.
3.1.1.3   Instruct others in learning new knowledge and acquiring new skills and learn from other team members.
3.1.1.4   Assist others who have less experience or have heavy workloads.
3.1.1.5   Encourage others to express their ideas and opinions.

3.1.2   Establishing productive relationships

3.1.2.1   Develop constructive and cooperative working relationships with others.
3.1.2.2   Exhibit tact and diplomacy and strive to build consensus.
3.1.2.3   Deliver feedback and constructive criticism and voice objections to others' ideas and opinions in a supportive, non-accusatory manner.
3.1.2.4   Respond appropriately to positive and negative feedback.
3.1.2.5   Effectively communicate with all members of a multi-disciplinary group or team to achieve team goals and objectives.
3.1.2.6   Use tools and approaches that facilitate a productive virtual team environment.
3.1.2.7   Mentor others.

3.1.3   Meeting team objectives

3.1.3.1   Work as part of a team, contributing to the group's effort to achieve goals.
3.1.3.2   Identify and commit to the goals, norms, values, and customs of the team.
3.1.3.3   Choose behaviors and actions that best support the team and accomplishment of work tasks.
3.1.3.4   Use a group approach to identify problems and develop solutions based on group consensus.
3.1.3.5   Identify elements of successful teamwork.

3.1.4   Resolving conflicts

3.1.4.1   Bring others together to reconcile differences.
3.1.4.2   Handle conflicts maturely by exercising "give and take" to achieve positive results for all parties.
3.1.4.3   Reach formal or informal agreements that promote mutual goals and interests, and obtain commitment to those agreements from individuals or groups.

3.2 Client/Stakeholder Focus: Efficiently and effectively addressing the needs of clients.

3.2.1   Understanding client needs
3.2.1.1   Identify internal and external clients/stakeholders.

3.2.1.2   Attend to what clients/stakeholders are saying and ask questions to identify their needs, interests, and goals.

3.2.1.3   Anticipate the future needs of the client/stakeholder.

3.2.2   Providing personalized service

3.2.2.1   Provide prompt, efficient, and personalized assistance to meet the requirements, requests, and concerns of clients/stakeholders.

3.2.2.2   Provide thorough, accurate information to answer clients'/stakeholders' questions and inform them of commitment times or performance guarantees.

3.2.2.3   Define the service needs of project stakeholder or product consumers so as to reflect their values and requirements.

3.2.2.4   Address client/stakeholder comments, questions, concerns, and objections with direct, accurate, and timely responses.

3.2.2.5   Identify and propose appropriate solutions and/or services.

3.2.2.6   Establish boundaries as appropriate for unreasonable client demands.

3.2.2.7   Acting professionally

3.2.2.8   Is pleasant, courteous, and professional when dealing with internal or external clients/stakeholders.

3.2.2.9   Develop constructive and cooperative working relationships with clients/stakeholders.

3.2.2.10   Is calm and empathetic when dealing with hostile clients/stakeholders.

3.2.3   Keeping clients/stakeholders informed

3.2.3.1   Follow up with clients/stakeholders during projects and following project completion.

3.2.3.2   Keep clients/stakeholders up to date about decisions that affect them.

3.2.3.3   Seek the comments, criticisms, and involvement of clients/stakeholders.

3.2.3.4   Adjust services based on client/stakeholder feedback.

3.3 Planning and Organizing: Planning and prioritizing work to manage time effectively and accomplish assigned tasks.

3.3.1   Planning

3.3.1.1   Approach work in a methodical manner.

3.3.1.2   Plan and schedule tasks so that work is completed on time.

3.3.1.3   Keep track of details to ensure work is performed accurately and completely.

3.3.1.4   Anticipate obstacles to project completion and develop contingency plans to address them.

3.3.1.5   Find new ways of organizing work area or planning work to accomplish work more efficiently.

3.3.2   Prioritizing

3.3.2.1   Efficiently prioritize multiple competing tasks.

3.3.2.2   Perform tasks correctly, quickly, and efficiently according to their relative urgency and importance.

3.3.3   Managing projects

3.3.3.1   Identify work tasks and budgets for a portion of a project and direct the project work of one or more team members.

3.3.3.2   Allocate time, resources and personnel effectively, to fulfill requirements and take corrective action if project goes off track.

3.3.3.3   Plan for dependencies of one task on another.

3.3.3.4   Coordinate efforts with all affected parties, keeping them informed of progress and all relevant changes to project timelines.

3.3.3.5   Compare the pros and cons of alternative design options.

3.3.3.6   Coordinate reasonable job accommodations for personnel who need or request them.

3.3.3.7   Formulate and keep track of documents, assignments, changes and deliverables to be incorporated into a project plan.

3.3.3.8   Analyze a project and formulate effective strategies within the context of the five processes of initiating, planning, executing, monitoring and controlling, and closing.

3.3.3.9   Estimate and manage personnel, costs and other resources needed for project completion using appropriate tools such as Gantt charts, other bar charts, precedence diagrams, critical path methods, and the earned value method.

3.4 Creative Thinking: Generating innovative and creative solutions.

3.4.1   Employing unique analyses

3.4.1.1   Learn and use facilitation tools and methods that encourage creative and innovative thinking by individuals and groups.

3.4.1.2   Use original analyses and generate new, innovative ideas in complex areas.

3.4.1.3   Develop innovative methods of obtaining or using resources when insufficient resources are available.

3.4.2   Generating innovative solutions

3.4.2.1   Consider past successful approaches while also being open to fundamentally new ones.

3.4.2.2   Integrate seemingly unrelated information to develop creative processes or solutions.

3.4.2.3   Reframe problems in a different light to find fresh approaches.

3.4.2.4   Entertain wide-ranging possibilities and perspectives to develop new solutions.

3.4.2.5   Find new ways to add value to the efforts of a team and organization.

3.4.3   Seeing the big picture

3.4.3.1   Understand the pieces of a system as a whole and appreciate the consequences of actions on other parts of the system.

3.4.3.2   Monitor patterns and trends to see a bigger picture.

3.4.3.3   Modify or design systems to improve performance.

3.4.3.4   Demonstrate an ability to create a vision.

3.5 Problem Solving, Prevention and Decision Making: Generating, evaluating, and implementing solutions to problems.

3.5.1   Identifying the problem
    3.5.1.1   Anticipate or recognize the existence of a problem.
    3.5.1.2   Recognize that problem-solving is based partly on the past because that is where the problems came from.
    3.5.1.3   Analyze existing conditions to identify the true nature of the problem and define critical issues.
    3.5.1.4   Use all available reference systems to analyze information relevant to understanding the problem.
    3.5.1.5   Evaluate the importance and criticality of the problem.
    3.5.1.6   Recall previously learned information that is relevant to the problem.
    3.5.1.7   Formulate ideas on how to prevent those problems in similar circumstances and share them with appropriate personnel.

3.5.2   Locating, gathering, and organizing relevant information
    3.5.2.1   Effectively use both internal resources (e.g., internal computer networks, company filing systems) and external resources (e.g., internet search engines) to locate and gather information relevant to solving the problem.
    3.5.2.2   Examine information obtained for relevance and completeness.
    3.5.2.3   Recognize important gaps in existing information and takes steps to eliminate those gaps.
    3.5.2.4   Organize/reorganize information as appropriate to gain a better understanding of the problem.

3.5.3   Generating alternatives
    3.5.3.1   Consider the causes and effects of current and recently-resolved technical and non-technical problems.
    3.5.3.2   Integrate previously learned and externally obtained information to generate a variety of high-quality alternative approaches to the problem.
    3.5.3.3   Skillfully use logic and analysis to identify the strengths and weaknesses, the costs and benefits, and the short- and long-term consequences of different solutions or approaches.

3.5.4   Choosing a solution
    3.5.4.1   Decisively choose the best solution after evaluating the relative merits of each possible option.
    3.5.4.2   Make difficult decisions even in highly ambiguous or ill-defined situations.

3.5.5   Implementing the solution
    3.5.5.1   Commit to a solution in a timely manner and develop a realistic approach for implementing the chosen solution.
    3.5.5.2   Document the problem and corrective actions taken and their outcomes and communicate these to the appropriate parties.

3.5.5.3	Observe and evaluate the outcomes of implementing the solution to assess the need for alternative approaches and to identify lessons learned.
3.5.5.4	Expedite projects by identifying tasks that can be done simultaneously, rather than assuming that they must be done in series.

3.6 Seeking and Developing Opportunities

3.6.1   Maintaining Perspective

3.6.1.2	Appreciate that the engineer can also think in a forward-looking problem avoidance and opportunity-seeking mode.
3.6.1.3	Incorporate the results of risk analysis as a driver for problem solving and risk mitigation in developing new opportunities.
3.6.1.4	Recognize that everyone plays a part in the development of opportunities for their organization, even indirectly by providing good service to clients and producing quality products.

3.6.2   Marketing

3.6.2.1	Be aware of potential clients/stakeholders and their wants and needs.
3.6.2.2	Uphold the organization through building and maintaining client/stakeholder relationships.
3.6.2.3	Share potential client/stakeholder information and product/service ideas with appropriate individuals in your organization.
3.6.2.4	Assist members of your organization with developing product/service ideas, building new relationships with potential clients/stakeholders, and making sales and securing contracts.
3.6.2.5	Look for unmet needs, poorly-served clients, suboptimal performance, and under-utilized resources and view them as opportunities for the organization.
3.6.2.6	Formulate ideas on how to pursue opportunities and share them with appropriate personnel.

3.7 Working with Tools and Technology: Selecting, using, and maintaining modern engineering tools and technology, including adaptive tools and new technology, to facilitate work activity.

3.7.1   Selection and application

3.7.1.1	Ascertain needs requirements of project to ensure proper tools and technology are selected for the current project.
3.7.1.2	Identify, evaluate, select, and apply hardware or software tools or technological solutions appropriate to the task at hand (e.g., use statistical tools to show reliability of data).
3.7.1.3	Identify the advantages and disadvantages of a tool applied within an engineer's area of specialization.
3.7.1.4	Identify potential hazards or risks related to the use of tools and equipment.
3.7.1.5	Analyze and interpret the results obtained with an engineering tool.
3.7.1.6	Develop and improve an engineering tool or its use.

| 3.7.1.7 | Operate tools and equipment in accordance with established operating procedures and safety standards. |
| 3.7.1.8 | Develop knowledge and skills with a new or updated tool, and apply the tool in the solution of an engineering problem. |

3.7.2 Keeping current on tools and technology

3.7.2.1	Seek out opportunities to improve knowledge of tools and technologies that may assist in streamlining work and improving productivity.
3.7.2.2	Demonstrate an interest in learning about new and emerging tools and technology.
3.7.2.3	Adapt quickly to changes in process or technology.

3.7.3 Troubleshooting and maintenance

3.7.3.1	Learn how to maintain and troubleshoot tools and technologies.
3.7.3.2	Apply maintenance and calibration for an engineering tool.
3.7.3.3	Determine causes of error and take the appropriate corrective action.
3.7.3.4	Develop alternatives to complete a task if desired tool or technology is not available.

3.8 Scheduling and Coordinating: Making arrangements that fulfill all requirements as efficiently and economically as possible.

3.8.1 Arranging and informing

3.8.1.1	Make arrangements (e.g. for meetings or travel) that fulfill all requirements as efficiently and economically as possible.
3.8.1.2	Inform others of arrangements, giving them complete, accurate, and timely information.
3.8.1.3	Ensure that others receive needed materials in time.
3.8.1.4	Handle all aspects of arrangements thoroughly and completely.
3.8.1.5	Respond to the schedules of others affected by arrangements, resolve schedule conflicts or travel issues, and take corrective action.
3.8.1.6	Disseminate crucial information in an organized manner to rapidly bring staff up to speed.

3.8.2 Coordinating in distributed environments

3.8.2.1	Coordinate schedules of colleagues, co-workers, and clients in regional locations. (i.e., across time zones) to ensure that inconvenience is minimized and productivity is enhanced.
3.8.2.2	Leverage technology (e.g., internet, teleconference) to facilitate information sharing in distributed work environments.
3.8.2.3	Take advantage of team member availability throughout business hours in multiple time zones to enhance productivity.

3.9 Checking, Examining, and Recording: Entering, transcribing, recording, storing, or maintaining information in written or electronic/digital format, including adaptive devices and software.

3.9.1   Capturing data

3.9.1.1   Record data in documentation.
3.9.1.2   Compile, code, categorize, calculate, inspect, or verify information or data.
3.9.1.3   Apply systematic techniques for observing and gathering data.

3.9.2   Detecting errors

3.9.2.1   Detect and correct errors or inconsistencies, even under time pressure.
3.9.2.2   Identify and clarify vague or ambiguous documentation.
3.9.2.3   Route errors to appropriate person to correct documentation.

3.9.3   Completing forms

3.9.3.1   Select and complete appropriate forms quickly and completely.
3.9.3.2   Forward or process forms in a timely and accurate manner.
3.9.3.3   Attend to and follow through on important items requiring action.
3.9.3.4   Expedite forms, orders, or advances that require immediate attention.

3.9.4   Obtaining information

3.9.4.1   Obtain appropriate information, signatures, and approvals promptly.
3.9.4.2   Verify that all information is present and accurate before forwarding materials.
3.9.4.3   Compile, categorize, and verify information or data.
3.9.4.4   Apply systematic techniques for observing and gathering data.

3.9.5   Maintaining logs, records, and files

3.9.5.1   Organize records and files to maintain data.
3.9.5.2   Keep logs, records, and files that are up-to-date and readily accessible (e.g., driver logs, flight records, repair records).
3.9.5.3   Update logs, records, and files, noting important changes.
3.9.5.4   File data and documentation in accordance with organization's requirements.

3.10 Business Fundamentals: Using information on basic business principles, trends, and economics.

3.10.1 Organizational context

3.10.1.1   Understand the mission, structure, and functions of the organization.
3.10.1.2   Recognize one's role in the functioning of the organization and understand the potential impact one's own performance can have on the success of the organization.
3.10.1.3   Grasp the potential impact of the company's well-being on employees.
3.10.1.4   Understand relevant legal and regulatory requirements of the operation.

3.10.2   Integrity in Business

    3.10.2.1   Act ethically in the best interest of the company, the community, and the environment.

    3.10.2.2   Comply with applicable laws and rules governing work and report loss, waste, or theft of company property to appropriate personnel.

3.10.3   Market knowledge

    3.10.3.1   Understand market trends in the industry and stay current on organizational strategies to maintain competitiveness.

    3.10.3.2   Recognize major challenges faced by the organization and industry and key strategies to address challenges.

Employment and Training Administration
United States Department of Labor
www.doleta.gov
Engineering Competency Model – May 2015   23

Tier 4 – Industry-Wide Competencies

4.1 Foundations of Engineering: Engineering fundamentals and its interactions with society.

4.1.1   Engineering Science

4.1.1.1   Identify and describe the basic principles of a related science and technology pertinent to a specific area of engineering practice.

4.1.1.2   Define key factual information in one or more applicable areas of engineering science as related to a project or product.

4.1.1.3   Employ principles, use knowledge and integrate concepts of one or more areas of engineering science into the design of or improvement of a project, project component or product and to solve engineering problems.

4.1.1.4   Apply critical thinking skills to a project or product based on knowledge of one or more areas of engineering science.

4.1.2   Natural Science

4.1.2.1   Use elements from one or more areas of natural science to aid in design.

4.1.2.2   Explain key concepts of the scientific method and/or associated inquiry processes to test basic theories in one or more areas of natural science as they apply to engineering projects.

4.1.2.3   Apply critical thinking skills through the application of the scientific method and/or associated inquiry processes in one or more areas of natural science.

4.1.2.4   Use the laws of science to solve engineering problems.

4.1.3   Humanities and Social Sciences

4.1.3.1   Evaluate general public input and develop that input into technical possibilities as appropriate.

4.1.3.2   Evaluate perspectives from local, state, or national culture or history and related societal trends in the development of a current project.

4.1.3.3   Arrange and help facilitate a meeting during which individuals with varied values will attempt to reconcile different desired outcomes of a project.

4.1.3.4   Evaluate, for a new technical development, institutional arrangements that will provide effective management of a facility or system, or mitigate public risks.

4.1.3.5   Identify the potential contribution of an emerging technology to the public good and evaluate mechanisms for its delivery such as private market or public ownership.

4.1.3.6   Compare the technical and nontechnical positive and negative features of alternative courses of action and discuss and evaluate these alternatives with decision-makers and stakeholders.

Typical (or Examples of) Knowledge Areas: *Engineers will be exposed to and called upon to demonstrate awareness of each of these areas, but knowledge mastery is not necessarily a requisite.*

4.1.4   Engineering Science

4.1.4.1   Fluid mechanics
4.1.4.2   Statics and Dynamics
4.1.4.3   Electric circuits
4.1.4.4   Solid mechanics
4.1.4.5   Thermodynamics
4.1.4.6   Heat transfer
4.1.4.7   Mass transfer
4.1.4.8   Materials properties

4.1.5   Natural Science

4.1.5.1   Physics
4.1.5.2   Chemistry
4.1.5.3   Biology
4.1.5.4   Geology

4.1.6   Humanities and Social Sciences

4.1.6.1   Philosophy
4.1.6.2   Business studies
4.1.6.3   Demography
4.1.6.4   Ethics
4.1.6.5   History
4.1.6.6   Literature
4.1.6.7   Visual and Performing Arts
4.1.6.8   Economics
4.1.6.9   Political Science
4.1.6.10   Sociology
4.1.6.11   Psychology

4.2 Design: The process of devising a system, component, or process to meet desired needs.

4.2.1   Design

4.2.1.1   Identify the pertinent technical, environmental, economic, regulatory, cultural and other project requirements and constraints.
4.2.1.2   4.2.1.2 Gather information needed to fully understand the problem to be solved and form the basis for the evaluation of design alternatives.
4.2.1.3   Contribute to the development of alternatives by analyzing the pros and cons of alternative design options, preparing those design options, and assisting in the selection of an optimized design alternative.
4.2.1.4   Analyze the constructability or manufacturing feasibility of a project or product.

4.2.1.5   Design a basic facility, structure, system, product, or process to meet well-defined requirements.

4.2.1.6   Apply lessons learned from other design projects.

4.2.1.7   Maintain knowledge of current types of systems, equipment, information technology, and specifications that accomplish specific design objectives.

4.2.1.8   Consider human factors and ergonomics for employees creating products and for users of those products.

4.2.1.9   Identify and use the appropriate strategies and processes to test design (e.g., rapid prototyping).

4.2.1.10   Use engineering software appropriate to one's engineering discipline.

4.2.1.11   Understand physical and cybersecurity and apply key concepts within the design of a project to ensure secure operations.

4.2.2   Technical Breadth and Depth

4.2.2.1   Integrate concepts of a related science or technology into design of a project, project component, or product.

4.2.2.2   Review research articles pertaining to a project component typically encountered in a specific area of engineering design.

4.2.2.3   Choose topics most appropriate for continuing education to increase depth of technical knowledge pertinent to the specific area of engineering practice.

4.2.2.4   Maintain knowledge of current types of systems, equipment, information technology, and specifications that accomplish specific design objectives.

4.2.3   Risk, Reliability and Uncertainty

4.2.3.1   Describe the meaning, importance, and significance of risk, reliability, and uncertainty for the protection of public health, safety, welfare, and security in the design of a facility, structure, process, system or product.

4.2.3.2   Determine the appropriate type and quantity of data required to identify ranges of existing and future conditions in defining a problem to be resolved through design.

4.2.3.3   Identify and assess risk, reliability, and/or uncertainty in the design of an engineered component, system, or process including its impacts on the environment, economy, and society.

4.2.3.4   Apply concepts of risk, reliability, and/or uncertainty as an integral part of engineering design and decision making.

4.2.3.5   Calculate the probability or frequency of occurrence and resulting impact of risk in the design of an engineered component, system, or process.

4.2.3.6   Explain to the public issues relating to risk, reliability, and/or uncertainty in the design of an engineered component, system, or process.

4.2.3.7   Compare the pros and cons of alternative design options and assist in the selection of an optimized design alternative based on risk, reliability, and/or uncertainty analysis.

4.2.4   Experiments

4.2.4.1   Apply knowledge of various experimental and prototyping methods.

4.2.4.2   Design and conduct experiments to test a hypothesis, such as the potential effectiveness of a proposed solution to an engineering problem.

4.2.4.3   Develop and recommend a plan of action based, in part on the experimental results.

4.2.4.4   Understand and apply the difference between accuracy and precision.

4.2.4.5   Understand and apply scale-ability or similitude.

4.2.5   Systems Engineering

4.2.5.1   Identify and gather information needed to understand a multidimensional problem to be solved and to form the basis for the evaluation of alternatives and design.

4.2.5.2   Contribute to the development of alternatives in complex projects.

4.2.5.3   Analyze the pros and cons of alternative design options and assist in the selection of an optimized design alternative based on overall system characteristics and performance.

4.2.5.4   Define, specify, and/or implement effective interfaces between system components and subsystems to meet system-level requirements.

Knowledge Areas:

4.2.6   Design

4.2.6.1   Schematics and diagrams
4.2.6.2   Operating parameters
4.2.6.3   Operating and non-operating environmental stimuli
4.2.6.4   External dimensions
4.2.6.5   Materials requirements
4.2.6.6   Reliability requirements
4.2.6.7   External surface treatment
4.2.6.8   Design life
4.2.6.9   Packaging requirements
4.2.6.10   External marking
4.2.6.11   Computer-aided design programs
4.2.6.12   "Design for X" (design within constraints)
4.2.6.13   Intellectual property
4.2.6.14   Design, control and integration of systems

4.2.7   Experiments

4.2.7.1   Test requirements
4.2.7.2   Maintenance and testability provisions
4.2.7.3   Digital computer models
4.2.7.4   Test protocol and procedures
4.2.7.5   Uncertainty analysis
4.2.7.6   Capabilities and limitations of test
4.2.7.7   Safety precautions

4.3 Manufacturing and Construction: The process by which materials are converted or assembled into higher value products.

4.3.1 Identify and prioritize the technical, environmental, economic, regulatory, and other requirements of a manufacturing or construction project.
4.3.2 Gather and analyze information to plan the manufacturing or construction process of a product or structure.
4.3.3 Analyze the pros and cons of some alternative manufacturing or construction processes and participates in the selection of the optimum approach.

Knowledge Areas:

4.3.4 Manufacturing processes
4.3.5 Infrastructure (e.g., transportation systems, water supply and wastewater systems, agriculture and food distribution, communication systems and other facilities, structures and systems supportive of daily life)
4.3.6 Automated and fast-tracked construction methods
4.3.7 Lean construction

4.4 Operations and Maintenance: The setup, operation, control, maintenance and improvement of technology that supports production to meet client requirements.

4.4.1 Identify, during the planning and design of a system or works, the likely operation and maintenance requirements.
4.4.2 Develop standard operating procedures and methods for the safe and reliable operation and maintenance of engineered systems and works.
4.4.3 Develop standards for maintenance that provide the greatest reliability of engineered systems and works given the scarce and limited resources that are available.
4.4.4 Gather and analyze information to enable the cost-effective allocation of resources that are available for maintenance to provide the highest levels of safety and reliability of engineered systems and works.
4.4.5 Identify and organize training necessary for technicians, supervisors, and workers so the organization has the capacity to effectively operate and maintain engineered systems and works.
4.4.6 Create and maintain the policies and procedures for the planning, organization, supervision, and management of the maintenance and operation of engineered systems and works.
4.4.7 Analyze the pros and cons of alternative operation and maintenance methods and select one.

Knowledge Areas:

4.4.8 Contracts
4.4.9 Material and resource management
4.4.10 Operator training
4.4.11 Personnel management methods
4.4.12 Project lifecycle

4.4.13	Project management tools and techniques

4.5 Professional Ethics: Displaying strong engineering ethics by evaluating and applying the merits, risks, and social concerns of activities in engineering.

4.5.1   Practice in an ethical manner, with personal and professional integrity.
4.5.2   Abide by one or more applicable (e.g., employer, professional society, client) strict code of ethics and behavior, even in the face of opposition.
4.5.3   Encourage others to behave ethically.
4.5.4   Understand that behaving ethically goes beyond what the law requires.
4.5.5   Use company time and property responsibly.
4.5.6   Perform work-related duties according to laws, regulations, contract provisions, and company policies.
4.5.7   Respect the need for confidentiality, when appropriate.
4.5.8   Analyze a situation involving multiple conflicting professional and ethical interests to determine an appropriate course of action.
4.5.9   Distinguish between a legal or management issue and an ethical matter.
4.5.10 Assemble appropriate resources to assist in the resolution of an ethical dilemma.
4.5.11 Formulate the solution to an ethical dilemma at the lowest management level possible, within the practice or management structure, and with the least amount of disruption as possible.
4.5.12 Select and take appropriate steps to record or to report to higher-level management or to public authorities in the event that an ethical matter is not adequately resolved in a manner consistent with the public health, safety, and welfare.

Knowledge Areas:

4.5.13 Codes of ethics (professional and technical societies)
4.5.14 Agreements and contracts and contract law
4.5.15 Ethical and legal considerations
4.5.16 Professional liability
4.5.17 Public protection issues (e.g., licensing boards)
4.5.18 NCEES Model Law and Model Rules
4.5.19 Intellectual property (e.g., copyright, trade secrets, patents)
4.5.20 Conflicts of interest

4.6 Business, Legal and Public Policy: The activities associated with business management and operations and the relevant local, state, federal, and international laws and regulations that impact engineering.

4.6.1   Business

4.6.1.1   Identify and distinguish among the various kinds of engineering practices, including corporate, academic, government, consulting, and self-employment.
4.6.1.2   Create and maintain the policies and procedures for the planning, organization, supervision, and management of the maintenance and operation of engineered systems and works.

4.6.2   Legal

4.6.2.1   Summarize the rationale for, and detailed requirements of, regulations pertinent to the individual's area of engineering practice.

4.6.2.2   Describe and interpret applicable codes in design and in construction or manufacturing.

4.6.2.3   Identify applicable standards and properly use those standards in preparing specifications before and during manufacturing and construction.

4.6.2.4   Prepare and interpret contract documents including coordinating plans, specifications, and construction contract provisions.

4.6.2.5   Recognize the ramifications of engineering decisions relative to professional and/or product liability.

4.6.3   Public Policy

4.6.3.1   Identify and/or engage with the various types of policy-making bodies including administrative, legislative, private, and quasi-public pertinent to a specific area of practice.

4.6.3.2   Explain how codes and standards are set and how public policy affects their development.

4.6.3.3   Describe how public policy affects engineering practice in an engineering discipline.

Knowledge Areas:

4.6.4   Business

4.6.4.1   Private, industrial and public engineering practices

4.6.4.2   Closely-held and publicly-held corporations, partnerships, sole practitioners

4.6.4.3   Overhead, profit, direct and indirect labor, cost, revenue

4.6.4.4   Contracts, costing approaches, fee structures

4.6.4.5   Characteristics of markets

4.6.4.6 Cost and pricing of products

4.6.4.7 Fundamentals of accounting

4.6.5   Legal and Public Policy

4.6.5.1   Applicable construction and manufacturing laws, regulations, standards and codes (e.g. OSHA regulations, MSHA mining regulations, Fire code of the National Fire Protection Association, National Electric Code, International Building Code, etc.)

4.6.5.2   National, state, local, and global requirements for industrial facilities

4.6.5.3   Pollution prevention regulations

4.6.5.4   Plans, specifications, and construction contract provisions

4.7 Sustainability and Societal and Environmental Impact: Meeting the needs of the present without compromising the ability of future generations to meet their own needs.

4.7.1   Sustainability

4.7.1.1   Strive to minimize waste, improve efficiency, and reduce resource use.

4.7.1.2   Operate with a triple bottom line, incorporating financial profitability, environmental integrity, and corporate social responsibility.

4.7.1.3   Understand life cycle analysis – the environmental and economic effects of a product at every stage of its existence, from extraction of materials through production to disposal and beyond.

4.7.1.4   Suggest and/or implement continuous improvement actions.

4.7.1.5   Abide by applicable international, federal, state, and local regulations and policies.

4.7.1.6   Safeguard the public interest.

4.7.1.7   Ensure equipment and systems are designed to minimize environmental impact.

4.7.1.8   Seek to upgrade processes beyond pollution control to pollution prevention.

4.7.1.9   Utilize advances in science and technology to upgrade levels of efficiency and environmental protection.

4.7.1.10   Promote sustainable business practices consistent with ISA 14001 International Environmental Management Guidance.

4.7.1.11   Identify information needed to understand and analyze the effects on the environment, economy, and society for a product, process, or system or components of them.

4.7.2   Societal Impact

4.7.2.1   Analyze the impacts of a project component on diverse stakeholders.

4.7.2.2   Estimate initial and life-cycle costs of a project and assess the impact of that cost and the benefits on users such as taxpayers or purchasers of a product.

4.7.2.3   Assess the intended and unintended environmental, economic, and societal impacts of project alternatives and explain the impacts of those alternatives to diverse project stake holders.

4.7.2.4   Prepare and deliver presentations to the public regarding the impacts of a project.

4.7.2.5   Understand the local and global environmental, economic, and societal impacts of decisions.

4.7.2.6   Integrate the arts and humanities with engineering.

Knowledge Areas:

4.7.2.7   Equipment, processes, and systems that minimize environmental impact

4.7.2.8   Pollution control and prevention

4.7.2.9   Reuse and recycling

4.7.2.10   Life cycle analysis

4.7.2.11   Sustainable business practices

4.7.2.12   Federal, state and local laws and regulations (e.g., water, wastewater, air, solid/hazardous waste, groundwater/soils)

4.7.2.13   ISO 14001 International Environmental Management Guidance

4.7.2.14   Ecosystems

Employment and Training Administration
United States Department of Labor
www.doleta.gov
Engineering Competency Model – May 2015   31

4.8 Engineering Economics: Economics for application to engineering projects.

4.8.1   Prepare detailed cost estimates of capital and annual operating costs, maintenance and repair, and replacement costs for a project or component of a project, such as equipment, materials, assembly, inspection, modification, quality assurance, etc.
4.8.2   Calculate the return on investment, present worth and/or annual cost and benefit of a project having initial capital and annual operation, maintenance, repair, salvage value and replacement costs using appropriate interest, discount, and projected inflation rates.
4.8.3   Identify and quantify the economic risks associated with a project or product, including how warranty costs are considered for a product.
4.8.4   Compare design alternatives with varying cost profiles on a present worth or annual cost basis.
4.8.5   Interact with managers and other professionals in providing project economic information and opinions of project costs in financial analysis and financing process.

Knowledge Areas:

4.8.6   Time value of money
4.8.7   Cost, including incremental, average, sunk and estimating
4.8.8   Economic analyses
4.8.9   Depreciation and taxes
4.8.10   Discounted cash flows (PW, EAC, FW, IRR, amortization)
4.8.11   Types and breakdown of costs (e.g., fixed, variable, direct and indirect labor)
4.8.12   Accounting (financial statements and overhead cost allocation)
4.8.13   Capital budgeting
4.8.14   Risk identification
4.8.15   Cost-benefit analysis
4.8.16   Profit and loss
4.8.17   Supply/demand
4.8.18   Net income statement, cash flow statement, balance sheet

4.9 Quality Control and Quality Assurance: Ensuring product and process meets quality requirements as defined by client specifications.

4.9.1   Understand and apply basic concepts associated with measuring quality.
4.9.2   Implement controls to support quality management.
4.9.3   Use quality management to ensure quality levels are maintained.
4.9.4   Seek new approaches and techniques to improve quality levels.
4.9.5   Employ audits and inspections to maintain the quality and continuous improvement process.
4.9.6   Correct the product and process to meet quality standards.
4.9.7   Support and maintain quality systems.
4.9.8   Prepare quality control and quality assurance specifications for a project component.
4.9.9   Apply or review quality control and quality assurance procedures on a project component.

4.9.10 Analyze the impact of quality control and quality assurance on project performance.

Knowledge Areas:

4.9.11 Corrective and preventive actions

    4.9.11.1 Document creation
    4.9.11.2 Eliminating non-conformities
    4.9.11.3 Verification and documentation

4.9.12 Improving quality

    4.9.12.1 Problem solving tools
    4.9.12.2 Sampling and charting
    4.9.12.3 Statistical process control

4.9.13 Quality assurance

    4.9.13.1 Industry standards
    4.9.13.2 Meeting client needs
    4.9.13.3 Quality management systems and tools

4.9.14 Quality assurance audits

    4.9.14.1 Audit procedures
    4.9.14.2 ISO 9000

4.9.15 Statistical process control methods

    4.9.15.1 Acceptance sampling
    4.9.15.2 Capability analysis/tolerances
    4.9.15.3 Factor analysis
    4.9.15.4 Inspection/test/validation
    4.9.15.5 Reliability analysis

4.10 Safety, Health, Security and Environment: Complying with standards and procedures for a safe, secure, and healthy work environment.

4.10.1 Ensure that equipment is being used safely.
4.10.2 Comply with local, federal and company health, safety, and environmental standards and regulations.
4.10.3 Identify unsafe or insecure conditions and take corrective action.
4.10.4 Conduct health, safety, and/or environmental incident and hazard investigations.
4.10.5 Conduct preventive health, safety, and/or environmental incident and hazard inspections.
4.10.6 Implement continuous improvement in health, safety, and/or environmental practices.
4.10.7 Evaluate and contrast the safety aspects of design alternatives for a process, project component, or product.
4.10.8 Identify and apply the most current safety-related regulatory requirements pertinent to a process, project component, product or specific area of engineering practice.

4.10.9   Understand the key mitigations for physical and cybersecurity and apply them where necessary for secure operations.

Knowledge Areas:

4.10.10 Continuous improvement in health, safety, security, and environment

4.10.10.1   Process safety and hazard analysis (e.g., layer or protection analysis, hazard and operability studies (HazOps) fault-tree analysis or event tree)
4.10.10.2   Analysis of health/safety/environmental data
4.10.10.3   Identification of projects and priorities
4.10.10.4   Root cause analysis

4.10.11 Environmental protection/waste management

4.10.11.1   Chemical hazard assessment
4.10.11.2   Design to minimize environmental impact

4.10.12 Investigations for health, safety, security or environmental incidences/hazards

4.10.12.1   Developing corrective actions
4.10.12.2   Documentation of findings
4.10.12.3   Follow-up investigation
4.10.12.4   Insurance (property)
4.10.12.5   Violations reports to proper authorities
4.10.12.6   Workers' compensation

4.10.13 Regulations

4.10.13.1   Hazardous material communication (HAZCOM)
4.10.13.2   Hazardous material handling and disposal (HAZMAT)
4.10.13.3   Hazardous material information system labeling and storage (HMS)
4.10.13.4   Regulations governing safe use of equipment
4.10.13.5   Role of the Occupation Safety and Health Administration (OSHA), the Environmental Protection Administration (EPA) or other appropriate regulatory bodies in the workplace
4.10.13.6   Trade compliance Department of Commerce
4.10.13.7   National Environmental Policy Act (NEPA)
4.10.13.8   Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)
4.10.13.9   Superfund Amendments and Reauthorization Act (SARA)

4.10.14 Safety procedures

4.10.14.1   Safe operation in confined spaces
4.10.14.2   First aid or first response procedures
4.10.14.3   Assessing material, equipment and fixtures for hazards
4.10.14.4   Lock/tag out practices
4.10.14.5   Material Safety Data Sheets (MSDS)
4.10.14.6   Response to shop emergencies
4.10.14.7   Safe evacuation of facility
4.10.14.8   Safe moving of materials

4.10.14.9   Safe, prescribed operation of equipment and tools

4.10.14.10 Use, maintenance and inspection of machine safeguards

4.10.14.11 Use of safety equipment

4.10.15 Physical and cybersecurity

4.10.15.1   Governance

4.10.15.2   Identification of assets to be managed

4.10.15.3   Protection of assets from physical and cyber threats

4.10.15.4   Detection of threats

4.10.15.5   Respond to incidents

4.10.15.6   Recover from incidents

4.10.15.7   Security standards, frameworks, industry regulations and guidance
- International Information Security Management Guidance (ISO 27001)
- Office of Homeland Security System and Physical Security Regulations
- ISA/IEC 62443 Cyber Security for Industrial Control Systems
- NIST Cybersecurity Framework

Employment and Training Administration
United States Department of Labor
www.doleta.gov
Engineering Competency Model – May 2015   35

Resources Reviewed

Resource	Developer	URL
Environmental Engineering Body of Knowledge 2009	American Academy of Environmental Engineers (AAEE)	http://www.cece.ucf.edu/bok/Report.htm
The Vision for Civil Engineering in 2025	ASCE	http://www.asce.org/vision2025
Achieving the Vision for Civil Engineering in 2025: A Roadmap for the Profession	ASCE	http://www.asce.org/vision2025
Civil Engineering Body of Knowledge for the 21st Century	ASCE	http://www.asce.org/CE-Body-of-Knowledge/
CDIO Syllabus	CDIO Initiative	http://www.cdio.org/benefits-cdio/cdio-syllabus/cdio-syllabus-topical-form
Engineering courses, including "Intro to Green Engineering", "Intro to Aeronautics", "Design for Manufacturability and Assembly" and "Seven Axioms of Good Engineering A Case Study Course: Learning From Failure"	NASA Academy of Program/Project and Engineering Leadership (APPEL)	http://appel.nasa.gov/curriculum/in-depth-courses/#engineering
CEWD Engineering Competency Model	CEWD	http://www.cewd.org/Documents/EngCompModel.pdf
TryEngineering for Counselors	TryEngineering.org, sponsored by the United Engineering Foundation	http://tryengineering.org/SCM/STANDARD/IEEE.html
Detailed course outlines	Project Lead the Way	http://www.pltw.org/our-programs/engineering/engineering-curriculum
Curriculum	Intel "Design and Discovery" Initiative	http://www.intel.com/content/www/us/en/education/k12/design-and-discovery/curriculum.html

Resource	Developer	URL
Engineering Body of Knowledge	National Society of Professional Engineers (NSPE)	http://www.nspe.org/sites/default/files/resources/nspe-body-of-knowledge.pdf
Criteria for Accrediting Engineering Programs	ABET	http://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2015-2016
Criteria for Accrediting Engineering Technology Programs	ABET	http://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-technology-programs-2015-2016
Curriculum	Butler Community College	http://butlercc.edu/outline/atc/Pre-Engineering_EN/documents/EN115outline200980.pdf
Curriculum	California Maritime Academy	https://www.csum.edu/web/academics/et/majors/facilities-engineering-technology
Curriculum	Idaho State University	http://isu.edu/cse/courses/engr/ce/
Transforming Undergraduate Education in Engineering, May 9-10 2013 Workshop Report	American Society for Engineering Education (ASEE)	http://www.asee.org/TUEE_PhaseI_WorkshopReport.pdf