

# **Proposed Revisions to ABET General Criteria 3 and 5: A Practitioner's Perspective\***

## **Introduction**

The National Academy of Engineering (NAE) organized the February 16, 2016 Forum on Proposed Revisions to ABET Engineering Accreditation Commission General Criteria on Student Outcomes and Curriculum (Criteria 3 and 5). According to NAE, the forum was “structured to stimulate and facilitate a productive dialogue about the Engineering Accreditation Commission’s process and proposed changes to ABET Criteria 3 and 5.”

Three weeks before the forum, I was invited to participate in the forum’s “Perspectives from the Profession” panel which included a five to ten minute presentation by each panelist and subsequent discussion. I gladly accepted the invitation because of my efforts as a practitioner and as part of a growing group of practitioner and academic volunteers to improve the formal education and pre-licensure experience of U.S. engineers.

I reviewed resource materials and then prepared this paper, as a supplement to my panel participation, to further explain and document my views. This paper was available to forum participants immediately after the panel presentations and discussion. I chose to comment in this paper, from a practitioner’s perspective, on these six topics related to the proposed criteria:

- Standing Appreciatively on the Shoulders of Others
- Bloom’s Taxonomy
- Licensure
- Innovation
- Meeting Needs
- The Elephant in the Room

Each topic is described including its relevance to one or both general criteria. Then a suggestion is offered for improving the general criteria. ABET program criteria, in contrast with general criteria, can be used to stimulate improvements in programs of specific engineering disciplines and most disciplines use them. However, this paper is restricted to offering ideas for improving general criteria.

---

\* Presented by Stuart G. Welsh, PhD, PE at the Forum on Proposed Revisions to ABET Engineering Accreditation Commission General Criteria on Student Outcomes and Curriculum (Criteria 3 and 5), National Academy of Engineering, Washington, DC, February 16, 2016. See Appendix A for the author’s short biography.

## Standing Appreciatively on the Shoulders of Others

Criteria 3 and 5 (ABET 2016) have had, and will continue to have, a major impact on engineering programs and how they are evaluated. Therefore, the process used to revise the criteria should include study of major relevant documents produced by volunteer academics and practitioners over the past decade or so. Some examples of these documents are:

- *The Engineer of 2020* (NAE 2004)
- *Educating the Engineer of 2020* (NAE 2005)
- *Civil Engineering Body of Knowledge for the 21<sup>st</sup> Century* (ASCE 2008)
- *Environmental Engineering Body of Knowledge* (AAEE 2009)
- *Guide to Engineering Management Body of Knowledge* (ASME 2010)
- *NSPE Engineering Body of Knowledge* (NSPE 2013)
- *Engineering Competency Model* (USDOL 2015)

Documents like these are important for two reasons. First, some aspects of the world of engineering practice have or are changing and, therefore, the documents may reflect what are now viewed as more important emphases or topics than they were years ago.

Second, such documents are products of the integrated effort over the last decade of many committed academics and practitioners representing a wide range of engineering disciplines. This kind of intense and diverse participation enhances the credibility of the resulting products.

In working through resource materials provided by ABET (2016), I find reference to use of most of the above documents as well as others. However, the last listed resource is not noted and may not have been reviewed. The *Engineering Competency Model* is the result of a collaborative effort between the U.S. Department of Labor and the American Association of Engineering Societies (AAES). Given that the AAES is a pan-engineering society, the model warrants attention. It includes what are referred to as capabilities with some potentially relevant ones being Creativity, Client/Stakeholder Focus, Seeking and Developing Solutions/Opportunities, and Engineering Economics.

***Suggestion:*** Given its recent completion and its pan-engineering representation, review the *Engineering Competency Model*, as well as other relevant documents, for possible use in refining the draft criteria.

## Bloom's Taxonomy

Educational psychologist Benjamin Bloom developed what became known as Bloom's Taxonomy for the cognitive domain (Bloom et al. 1956). His goal was to find a way to describe learning outcomes so that students could understand them and faculty could assess them. His solution is to begin each outcome statement with an action-oriented verb. While subsequent investigators have offered improvements to the original

taxonomy, such as adding affective and psychomotor domains (Wikipedia 2016), the basic structure is still intact and is directly and usefully applicable to Criterion 3. Bloom's original taxonomy for the cognitive domain is organized in these six ascending levels: Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation. Examples of action-oriented verbs suggested for the first or Knowledge level are define, describe, identify, and list. In contrast, some fourth or Analysis-level verbs are select, organize, compare, formulate, and deliver. Note the specificity and differentiation of the action verbs.

The proposed Criteria 4 (ABET 2016) continues to use the now almost two-decade "ability to" format or construction. Consider the proposed communication outcome as an example. It says that, by completion of an undergraduate engineering program, documented student outcomes must include:

"An ability to communicate effectively with a range of audiences."

Bloom's Taxonomy can be used to add clarity to that outcome for the benefit of students -- so they understand what is expected -- and for the benefit of faculty -- so they can assess students' cognitive achievement in the area of communication. A possible Bloom-based version of the proposed communication outcome is:

"Organize and deliver effective communication with a range of audiences."

The active verbs "organize" and "deliver" are taken from Bloom's Analysis level, his fourth level, which is appropriate for graduates of a baccalaureate engineering program.

We could further communicate the communication outcome's intent by writing it as follows:

"Organize and deliver effective verbal, written, and visual communication with a range of audiences."

Adjectives have been added to increase the outcome's specificity.

Having used communication as an example, I am prompted to share an observation about engineering practitioners. Too many do "A" work and then present it in a "C" or worse manner. Accordingly, they earn a "C" or worse from those they serve or work with.

These engineers fail to apply easily-understood principles of effective writing, speaking, and use of visuals. For example, they write in the passive voice, speak with their backs to the audience, and show primarily bulleted slides while research indicates that the most effective slides are those that combine a declarative statement and a supportive image. My experience with engineering students and young practitioners is that if you tell them why communication is important and show them the basics of how to do it, they understand and they perform well. But I digress.

**Suggestion:** Regardless of the content of the next round of Criterion 3 outcomes, construct them in accordance with Bloom's Taxonomy so that they are more clearly understood by students and more readily assessed by faculty.

## **Licensure**

As has been the case for decades, the general criteria are silent on licensure. I think this has been a serious omission and now we have the opportunity to fix it. From my practitioner perspective, I offer three reasons to modify the general criteria so that engineering students learn about licensure.

*1) Distinguished performance:* In my view, licensed practicing engineers are generally distinguished from unlicensed practicing engineers in these three ways:

- They are more likely to be technically and otherwise current partly because of continuing education requirements
- They are explicitly expected by licensing boards to be ethical, with focus on public health, safety, and welfare (HSW)
- They tend to view themselves as members of a profession whose paramount responsibility is protection of public HSW rather than being primarily technical employees answerable mainly to corporate expectations

I believe that most faculty and their institutions would want their engineering graduates to be part of a group with the preceding characteristics.

*2) More Opportunities:* In a dynamic, volatile employment environment, the engineer practitioner who holds one or more professional engineer licenses will be better positioned, than the unlicensed practicing engineer, to move on to another employer if circumstances require it or opportunities arise. While job security is largely history for engineers, career security is within the reach of most engineer practitioners provided that they are licensed to practice. In addition, we increasingly hear about self-employment and other forms of entrepreneurship which, in the engineering world, will be more available to licensed professionals.

As a manager in business and government organizations, I interviewed many soon-to-graduate engineers and experienced engineers and hired a small fraction of them. To the best of my memory, I never hired anyone that was not a licensed engineer or on the track to become one. Whatever their other assets might have been, candidates without the license or intent to earn one did not demonstrate sufficient commitment to practice the profession, especially its public HSW responsibility, or appreciation for how they and our organization could leverage their license to serve our clients/stakeholders.

*3) Enhanced Attractiveness to Young People:* Today's smart social media-using high school students and their parents and counselors are very capable of gathering information on various professions. They could easily learn that a license is required for

those professionals who practice accounting, architecture, audiology, dentistry, law, medicine, physician assistant, psychiatry, psychology, occupational therapy, optometry, pharmacy, physical therapy, and veterinary medicine. Yet, because of the industrial exemption (NSPE 2011), many unlicensed engineers practice engineering in situations where public HSW are at stake.

I want engineering to attract the most intelligent and aspiring young people. What are the bright and motivated high school students, their parents, and their counselors asking today about engineering and other professions and what are they thinking about the answers? How does engineering stack up in their eyes compared to all those professions that require a license to practice?

Another indication of the importance of licensure in engineering practice is that it is used as critical event in a practicing engineer's career. For example, bodies of knowledge developed in recent years by engineering societies (ASCE 2008, NSPE 2013, Russell and Lenox 2013) use licensure as the career milestone at which the respective body of knowledge is to be achieved.

Bottom line: Earning an engineering degree and then not taking the Fundamentals of Engineering Examination while still in college is like running a marathon and quitting ten yards short of the finish line or buying a sports car and leaving it in the garage.



Urge students not to “buy” the arguments that licensure is a shallow prestige credential or their employment will be secure as long as they maintain their technical competence. These claims serve some large employers of engineers, not individual engineers or public HSW.

### **The Ignition Key Disaster**

Consider a true short story (Mathews and Spector 2015, Pine 2014, Spector 2015, Stout 2015, Valukas 2014) about engineering, licensure, ethics, business, and public HSW. I am not telling this story to prove anything – stories usually don't do that. The value of this story is that it illustrates connections within engineering practice among licensure, ethics, business, and public HSW. Furthermore, the story suggests how its use could be an effective, efficient, and memorable way to introduce engineering students to the value of licensure and the need for ethical behavior.

It's 2002 at General Motors (GM). Ray DeGiorgio, who held a BS in mechanical engineering and was apparently unlicensed, approved the design of an ignition switch that, time would tell, failed to meet GM standards – too little torque to turn the key. As a result, the ignition could be accidentally shut off while a GM vehicle was being driven (e.g., driver's knee touches the ignition key) which disarmed airbags, shut down power steering and brakes, and stopped other systems. (Note: In this discussion, I characterize some engineers as “apparently unlicensed” based on the accounts described in the cited sources and on the fact that, as of August 2015, a visit to the State of Michigan licensing board website revealed that only one of the approximately ten engineers named in the study was licensed to practice engineering.)

While GM was in the process of selling about two million vehicles containing the flawed switch worldwide in the mid-2000s, its mostly apparently unlicensed engineers learned that some GM cars with the defective switches were involved in accidents resulting in injuries and deaths to drivers and passengers. They **did not recommend a recall**.



However, in 2006, engineer DeGiorgio quietly led the design of a new switch that met GM specifications. Once again, he and others **did not recommend a recall** (they hid the redesign of the switch by not assigning a new part number) so that about two million defective cars remained on the road around the globe. Into the late 2000s, GM continued to receive information about the dangerous and often deadly consequences of the original switch, but the mostly unlicensed engineers still **did not recommend a recall**.

Finally, in 2014 after a decade of irresponsible action by GM engineers, GM recalled about two million vehicles and various types of litigation began. As of May of 2015, 107 deaths, 199 injuries, and 3350 claims were attributed to the ignition switch disaster caused mainly by the unethical acts of GM engineers. The company paid a \$35,000,000 fine in 2014, faced criminal charges, and fired Ray DeGiorgio and 14 other employees including engineers. The story continues to this day. Incidentally, Mary Barra, an electrical engineering graduate and GM CEO, is not a licensed engineer.

In my view, the GM ignition switch disaster would not have happened, or been as severe, if the GM engineers had been licensed. Why? Because 50 years of experience as a licensed engineer in the academic, public, and private sectors lead me to the conclusions presented in item Number 1 near the beginning of this licensure discussion. To reiterate,

licensure is directly connected to public HSW. Because of the industrial exemption, only about 20 percent of practicing engineers in the U.S. are licensed. This invites more disasters.

***Suggestion:*** You may not, for whatever reason, want to become a licensed engineer. However, give engineering students sufficient information to make sound decisions about the public HSW purpose of licensure and the career opportunities licensure offers. Find a way to mention licensure in Criteria 3 or 5. For example, revise the second sentence in Criterion 5c to read “Students must be prepared to enter the professional practice of engineering through a curriculum culminating in major design experience based on the knowledge and skills acquired in earlier course work, incorporating appropriate engineering standards and multiple constraints, *and recognizing the role of the licensed engineer in protecting public health, safety, and welfare.*” (Italicized text added.)

## **Innovation**

I was pleased to see that the charge to the C3 Task Force (Orr 2014) included a strong statement about innovation. The Task Force was charged with assessing, evaluating, and recommending improvements to Criterion 3 and the process “should consider the definition of **engineering in a global context** and **encourage innovation** and differentiation in engineering education and the engineering profession rather than conformity.” (bold not added.)

Furthermore, I was encouraged to see innovation mentioned in two areas, that is, engineering education and engineering practice, especially the first because it could stimulate and drive the latter. Then, on close review of the proposed Criteria 3, I sadly realized that innovate, innovation, create, creativity, and similar words are not to be found.

I see this as a serious omission given the above charge and in light of rapidly changing social, economic, and technological conditions that will increasingly challenge U.S. educated engineers. Some indicators of those challenges are: NAE’s Grand Challenges (NAE 2016), Kao’s (2007) argument that we need to prepare students to take on “wicked problems,” Pink’s (2005) assertion that we should move from a knowledge age mentality to a conceptual (creative) age mentality, and Naisbitt’s (2006) argument that we need to shift engineering from a primarily problem-solving only mode to a problem-solving and opportunity-seeking one.

We must tell students that creativity/innovation are important and convince them that these abilities are mostly a matter of nurture, not nature. Then explain the basics of how that three-pound marvel between their ears works and give them whole-brain tools to use. This can be readily done given the typical admirable intellect and work ethic of engineering students (Walesh 2016).

I am aware of the claim that reducing the number of outcomes in Criterion 3 will “invite innovations” (e.g., Larson et al. 2014) because “less is more.” My practice experience suggests otherwise. We tend to get what we explicitly expect, provided we provide commensurate support, whether we are clients expecting service or engineering organization managers/executives expecting performance. What gets described and then measured gets done. Engineering educators, in keeping with the aforementioned charge, are much more likely to innovate in their teaching and their students are much more likely to be innovative, first as students and then as practitioners, if innovation is an expectation of accredited engineering programs.

I suspect that very few engineering programs take a systematic approach to creativity and innovation. This conclusion is presented and supported for civil engineering (CE) in my paper (Walesh 2015). The conclusion is stated as follows: “I conclude that the Civil Engineering Body of Knowledge gives minimal attention to creativity/innovation, that Creativity/innovation are not widely taught and learned in CE bachelor programs, and that creativity/innovation fundamentals are not acquired during pre-licensure experience. Unless further investigation convinces me otherwise, we are not preparing U.S. civil engineers to be creative/innovative. Yes, some will because of personal characteristics and fortuitous circumstances. However, we could and should do much better for the sake of individual engineers and for the benefit of society. A rising tide would lift all boats.”

***Suggestion:*** Explore ways to explicitly mention creativity/innovation in the next proposed Criterion 3 or 5. Options include a creativity outcome or a creativity/innovation theme. Either of these would not require many words, just carefully chosen ones. For example, revise the first sentence in Criterion 5c to read “a broad education component that includes humanities and social sciences, *stimulates creativity/innovation*, complements the technical content of the curriculum, and is consistent with the program educational objectives. (Italicized text added.)

## **Meeting Needs**

Many students go through their entire undergraduate engineering program and are never engaged in discussions about being aware of and meeting needs. Yes, students will be *given* many problems to solve but have little if any explicit exposure to *identifying* problems to be solved or opportunities to be pursued in the interest of meeting societal, organizational, and individual needs.

Howard Schultz, CEO of Starbucks, said “We’re in the people business serving coffee, not in the coffee business serving people” (Behar 2009). We can paraphrase his comment for the engineering profession as follows: “We are in the people business serving engineering, not in the engineering business serving people.”

I suspect that many of us were drawn to engineering by fascination with and love of things, phenomena, and processes. For me it was water. As a boy I played with water

where a creek flowed into Lake Michigan and built dams and levees and dug canals and wells.



Much later I learned that if I studied civil engineering, I could continue to “play” with water and get paid for it. So I studied and worked with water for several decades. In the process, I gradually learned a lesson. While working with water was a continuous source of satisfaction and required maintaining my competence, being able to do it successfully required awareness of the needs of people and their organizations.

The successful practicing engineers I know complement their technical competence with a strong people orientation. They seem to have learned that most people don’t care how much we know until they know how much we care. Or maybe they have learned what poet Maya Angelou learned. She said: “I’ve learned that people will forget what you said, people will forget what you do, but people will never forget how you made them feel.”

Today’s students don’t have to wait. We can give them a head start, help them begin to see the wisdom of being in the people business long before they graduate. And in the process, they will be increasingly aware of issues to be resolved, problems to be solved, and opportunities to be pursued. That enhanced awareness could be fertile ground for some creative and innovative initiatives.

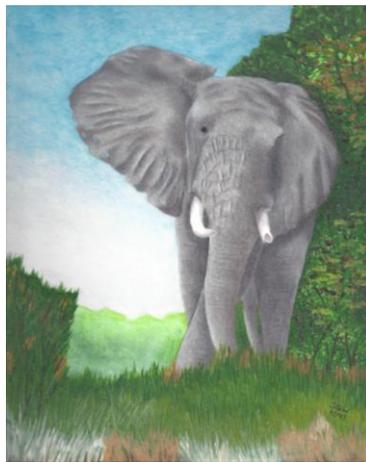
**Suggestion:** No, I am not about to call for a Meeting Needs outcome. Instead, I am urging us to find a more nuanced way to help sensitize engineering students to the human side of their chosen field. One option is to modify the proposed Outcome 7. It could read as follows: “An ability to function effectively on teams that *identify organizational or societal needs and then* establish goals, plan tasks, meet deadlines, and analyze risk and uncertainty *in the process of meeting those needs*. (Italicized text added.)

## **The Elephant in the Room**

As I tracked the evolving process leading to the current proposed Criteria 3 and 5 (e.g., ABET 2016, Larson et al. 2014, Orr 2014), I noticed a desire by some participants to reduce the number of outcomes. The original 11 outcomes went down to six and then as low as five before moving up to seven outcomes in the current draft for a net reduction of four.

Various reasons were given for reducing the number of outcomes in the next General Criterion 3 such as providing an environment that would, as noted earlier, "invite innovation" because "less is more" (Larson et al. 2014). Another reason given, over many years, for reduced outcomes is that ABET is always trying to put too much into the baccalaureate engineering program.

Then we have those participants who, throughout the outcome review process, urged adding more topics to existing outcomes or adding more outcomes. Examples of suggested new topics are: political constraints, constructability and manufacturability, diversity, and application of ethics. In summary, **some of us want fewer outcomes so that we can do more and others of us want more outcomes so that we can do more. Both groups are hindered by the four-year model.**



The elephant in the room is the ever-increasing and now decades-long concern with trying to get more out of or trying to stuff more into the four-year program. We simply cannot stuff ten pounds into a five-pound bag.

The elephant includes resistance to exploring an expanded basic education for U.S. engineers. However, we have seen some movement. In 2004, NAE -- our host for this forum -- published *The Engineer of 2020: Visions of Engineering in the New Century*, which concluded that "...if the engineering profession is to take the initiative in defining its own future, it must... agree on an exciting vision for the future; transform engineering education to help achieve the vision..." This conclusion clearly indicates that the time had arrived for all of U.S. engineering to reform, not refine, the preparation of tomorrow's engineers.

Then in 2005, NAE produced *Educating the Engineer of 2020: Adapting Engineering Education to the New Century*. This document concluded: "...it is evident that the exploding body of science and engineering knowledge cannot be accommodated within the context of the traditional four-year baccalaureate degree." The report recommended that **the baccalaureate degree be considered as a pre-engineering or Engineer-in-Training degree and the master's degree be regarded as the professional degree.**

Some related actions have been taken by engineering professional societies. For example, in 1998, ASCE (ASCE 2014, Russell and Lenox 2013) adopted the first version of Policy Statement 465 which, in today's refined form, states that ASCE supports requirements for licensure consisting of:

- “a baccalaureate degree in engineering;
- a master's degree in engineering, or no less than 30 graduate or upper level undergraduate technical and/or professional practice credits or the equivalent agency/organization/professional society courses which have been reviewed and approved as providing equal academic quality and rigor with at least 50 percent being engineering in nature; and
- appropriate experience based upon broad technical and professional practice guidelines which provide sufficient flexibility for a wide range of roles in engineering practice.”

**Suggestion:** Acknowledge the elephant. Take it on in one forward-looking collaborative and scholarly bite at a time with the goal of raising the education bar for all U.S. engineers. Engage a diverse group of participants from academia and practice. In a “begin with the end in mind” spirit, start by defining an aspirational set of outcomes or a body of knowledge for all engineering disciplines that are not limited by preconceived notions of numbers of years or credits. Then back into the kind of educational program that will provide all engineers with the desired result.

### Summary of Suggestions

This paper’s purpose is to offer my perspectives, as an engineer practitioner, on proposed changes to ABET Criteria 3 and 5. Accordingly, as developed in this paper, my suggestions in summary form are:

- 1) Review the recently published *Engineering Competency Model* (USDOL 2015), as well as other relevant documents that may not have been examined, for possible use in further improving the draft general criteria so as to build on and benefit from the work of predecessors.
- 2) Regardless of the content of the next round of Criterion 3 outcomes, construct them in accordance with Bloom’s Taxonomy so that they are more clearly understood by students and their achievement more readily assessed by faculty.
- 3) Use Criterion 3 or 5 to assure that students get sufficient information to make sound decisions about the public HSW purpose of licensure and the career opportunities that licensure offers.
- 4) Find a way to explicitly mention creativity/innovation in the next proposed Criterion 3 or 5 so that all engineering students understand the importance of

creativity/innovation and appreciate that these abilities are mostly a matter of nurture, not nature.

5) Employ a way, perhaps using Outcome 7, to more fully sensitize engineering students to the human side of their chosen field so that they expand their horizons to include but go way beyond solving problems given to them by others.

6) Mount a forward-looking collaborative and scholarly effort to address the elephant in the room, the increasingly unrealistic four-year model for the basic education of U.S engineers.

I hope that leaders of ABET, professional societies, and licensing boards and that academics and practitioners at the grass-roots level will find value in the information, ideas, and recommendations presented in this paper.

---

## Cited Sources

ABET. 2016. "Reference Materials on ABET Engineering Accreditation Commission (EAC) Revisions to Criteria 3 and 5," Baltimore, MD.

American Society of Civil Engineers. 2008. *Civil Engineering Body of Knowledge for the 21<sup>st</sup> Century-Second Edition*, ASCE, Reston, VA.

American Society of Civil Engineers. 2014. "Policy Statement 465 - Academic Prerequisites for Licensure and Professional Practice," Approved by the ASCE Public Policy Committee on September 3, 2014.

American Academy of Environmental Engineers. 2009. *Environmental Engineering Body of Knowledge*, AAEE, Annapolis, MD.

American Society of Mechanical Engineers. 2010. *Guide to Engineering Management Body of Knowledge*. ASME, New York, NY.

Behar, H. 2009. *It's Not About the Coffee: Leadership Principles for a Life at Starbucks*, Penguin Group, New York, NY.

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

Kao, J. 2007. *Innovation Nation: How America Is Losing Its Innovation Edge, Why It Matters, and What We Can Do To Get It back*, The Free Press, New York, NY.

Larson, D., R. McKean, and S. Cramer. 2014. "Learning Outcomes: Less Is More," *Prism*, ASEE, February, p. 54.

Matthews, C. M., and M. Spector. 2015. "GM Likely to Face Criminal Charges," *Wall Street Journal*, May 26.

Naisbitt, J. 2006. *Mind Set! Reset Your Thinking and See the Future*, HarperCollins, New York, NY.

- National Academy of Engineering. 2004. *The Engineer of 2020: Visions of Engineering in the New Century*, NAE, Washington, D.C.
- National Academy of Engineering. 2005. *Educating the Engineer of 2020: Adapting Engineering Education to the New Century*, NAE, Washington, DC.
- National Academy of Engineering. 2016. "Grand Challenges for Engineering," NAE, Washington, DC. (<http://www.engineeringchallenges.org/cms/challenges.aspx>), Accessed February 10, 2016.
- National Society of Professional Engineers. 2011. "Industrial Exemptions-Professional Policy No. 173," NSPE, Alexandria, VA. (Recommends phasing out of existing industrial exemptions in state licensing laws.)
- National Society of Professional Engineers. 2013. *NSPE Engineering Body of Knowledge*, NSPE, Alexandria, VA. (Available at no cost as a pdf from the NSPE website at <http://www.nspe.org/sites/default/files/resources/nspe-body-of-knowledge.pdf>), Accessed January 31, 2016.
- Orr, J. 2014. "Proposed Revisions to Criteria 3 and 5," PowerPoint presentation, July 11.
- Pine, A. 2014. "The Switch from Hell," *Prism*, ASEE, November, pp. 25-29.
- Pink, D. H. 2005. *A Whole New Mind: Moving From the Knowledge Age to the Conceptual Age*, Riverhead Books, New York, NY.
- Russell, J. S. and T. A. Lenox. 2013. *Raise the Bar: Strengthening the Civil Engineering Profession*, ASCE, Reston, VA.
- Spector, M. 2015. "Former GM Engineer to Testify Over Defect," *Wall Street Journal*, May 28.
- Stout, H. 2015. "Claims for GM Funds Pour In," *The New York Times*, January 31.
- U. S. Department of Labor. 2015. "Competency Model Clearing House-Engineering Competency Model," (<http://www.careeronestop.org/CompetencyModel/competency-models/engineering.aspx>), Accessed January 24, 2016.
- Valukas, A. R. 2014. *Report to Board of Directors of General Motors Company Regarding Ignition Switch Recalls*, May. (This report drew on 350 interviews with 230 persons and millions of documents.)
- Walesh, S. G. 2015. "Creativity and Innovation as Part of the Civil Engineering BOK," proceedings of the ASEE Annual Conference, June.
- Walesh, S. G. 2016. *Introduction to Creativity and Innovation for Engineers*, Pearson, Hoboken, NJ.
- Wikipedia. 2016. "Bloom's Taxonomy," ([https://en.wikipedia.org/wiki/Bloom's\\_taxonomy](https://en.wikipedia.org/wiki/Bloom's_taxonomy)), Accessed February 1, 2016.
- Image sources: Sports car-author, wrecked car-pixabay, creek-author, elephant-author.

---

## Appendix A: Author's Biography

Stuart G. Walesh, PhD, PE, Dist.M.ASCE, D.WRE, and F.NSPE is an independent consultant providing engineering, leadership, management, and education/training services. Prior to beginning his consultancy, he worked in the academic, government, and business sectors serving as a professor, dean, project engineer and manager, department head, discipline manager, marketer, and litigation consultant. Walesh participated in or managed many projects related to his technical specialty, water resources engineering.

He authored six books and many engineering publications and presentations. A recent book is *Engineering Your Future: The Professional Practice of Engineering* (Wiley, 2012) and his book *Introduction to Creativity and Innovation for Engineers* was just published by Pearson (<http://www.helpingyouengineeryourfuture.com/managing-leading-books.htm>). Walesh facilitated and/or made presentations at several hundred workshops, seminars, classes, webinars, and meetings throughout the U.S. and internationally. Over the past 15 years he has been active, as a practitioner, in the effort to reform the education and early experience of engineers. During the past six years he studied, wrote, spoke, and taught about how to use recently discovered basic brain knowledge coupled with whole-brain methods to help individual engineers and their teams and organizations work smarter, that is, be more effective, efficient, and creative/innovative.

Walesh has been recognized with awards from ASCE, Consulting Engineers of Indiana, Indiana Society of Professional Engineers, NSPE, University of Wisconsin, and Valparaiso University. He can be contacted at [stuwalesh@comcast.net](mailto:stuwalesh@comcast.net). For additional information, see: [www.helpingyouengineeryourfuture.com/index.htm](http://www.helpingyouengineeryourfuture.com/index.htm)

---