Thoughts on Design

... is design what Engineers do?.

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An acceptable definition of the term "design" continues to be elusive. The problem starts on campus in our undergraduate programs, shifts to industry hiring expectations and ends up as an issue surrounding the reporting of professional updating.

On campus, "design" must meet the constraints imposed by the Canadian Engineering Accreditation Board (CEAB). The difficulty here is that CEAB seems to have two views of "design".

Section 3.1 of the CEAB Accreditation Criteria and Procedures, lists and defines a dozen "*Graduate attributes*". In Section 3.1.4 it notes, "*Design: An ability to design solutions for complex, open-ended engineering problems and to design systems, components or processes that meet specified needs with appropriate attention to health and safety risks, applicable standards, economic, environmental, cultural and societal considerations*." Note the mention of "*. . . specified needs . . .*" .

Interestingly, when one looks at Section 3.1.1, "*A knowledge base for engineering*", design is not included in the list of competencies this "attribute" covers. If design isn't an element of basic Engineering knowledge, what is it? Is it simply answering questions that have pre defined "*specific needs*"? Is it an individual skill acquired through individual effort?

This definition makes sense for the 18 to 25 year old students who are attempting to gain an understanding of the technical skills future employers expect them to have. But it also leaves them with the feeling that they will be provided with the necessary inputs when they are called upon to "design" something.

Then, four pages later in Section 3.3.4.3, we find a broader definition, "*Engineering design integrates mathematics, natural sciences, engineering sciences, and complementary studies in order to develop elements, systems, and processes to meet specific needs. It is a creative, iterative, and open-ended process, subject to constraints which may be governed by standards or legislation to varying degrees depending upon the discipline. These constraints may also relate to economic, health, safety, environmental, societal or other interdisciplinary factors.*". The two terms that stand out in this definition are "*. . . integrates . . .*" and "*. . . subject to constraints . . .*". Certainly more inclusive, but apparently not a part of "*A knowledge base for engineering*".

Shifting to expectations at the hiring level, there is no question that employers seek individuals who understand and can use all the latest technical tools. We academics are told that graduates are expected to view "design" more in the light of Section 3.3.4.3, with an emphasis on the integration of technical skills and the identification of constraints. They are also expected to contribute as part of a design team. At this point, "design" shifts to requiring individual input to a broad team goal that has seemingly continually varying constraints. The task now is to find acceptable solutions to problems, not correct answers to questions. Individuals must be able to communicate their technical input to others in their technical team. The definition has changed.

The other change that enters the picture is that of precision vs accuracy. During undergraduate courses, students become skilled in applying analysis techniques that produced precise answers to the constrained questions they were assigned. Assuming that the given inputs were correct, then the answer obtained should also be correct. But "on the job", the inputs often become variables rather than constants. Part of the design task is to select "acceptable" inputs. Once those inputs are used in the analysis tools, precise answers can be produced. But are they accurate? Suddenly the new graduate is faced with the option of being approximately right, or precisely wrong. It all depends on the numbers being used, which may be little more than an educated guess. At this stage, "design" begins to encompass problem definition, configuration assumption, variable selection; all within the constraints of codes, standards, economics and time.

With the passage of time, each engineer gains experience and a broadened view of some part of our "engineering world". Over that same period of time, new analysis techniques emerge and, for most of us, our "cutting edge" technical skills are replaced by a greater appreciation of the fuller scope of our particular area of practice. Again "design" has acquired a different, more variable definition.

My assessment leans heavily on the front end of the process because we have relatively clear CEAB definitions. The profession has created a specification for the "academically qualified graduate" and I have extracted what I believe to be the definition of the "design" component from that specification. The steps beyond that point become more anecdotal. This is understandable because our profession has a multitude of specific needs beyond the "entry" requirements. Each of us develops a professional profile that reflects the needs we have been exposed to. Each of us looks upon our profile as the essence of design.

Maybe this is at the heart of the "design definition" problem. We can, within limits, define attributes of new graduates. The attributes reflect skills of "typical" graduates from "typical" programs. We can, within broader limits, define the expansion of attributes through the EIT process. Beyond that point, we seem hard pressed to define Engineering in general and incapable of developing a definition broad enough to fit the breadth of our profession.

If design is what Engineers do, maybe we should just leave the "doing" to individuals in their specific professional requirements and stop worrying about a universal definition.