InFocus | The Nature of Competence

By Jon A. Schmidt, P.E., SECB

The purpose of engineering licensure is to verify that anyone who may legally accept responsible charge of an engineering assignment has demonstrated at least minimal competence in the relevant discipline. But what constitutes competence? And what degree of competence is an appropriate threshold?

The fact that we are concerned with competence reflects how engineering is as much an art as a science, requiring knowledge-how as well as knowledge-that ("Engineering as Knowledge-How," November 2011). In other words, engineering involves the exercise of *skill*, not just awareness of facts and techniques. It is therefore useful to consider how people develop skills in order to gain a better understanding of what it means to be competent and what it takes for someone to become competent.

Philosopher Hubert Dreyfus and his brother Stuart, an industrial engineer, proposed a popular model of skill acquisition in conjunction with their work on the (in)feasibility of artificial intelligence ("What Computers Can't Do," November 2009). Using a phenomenological approach, they studied "unstructured" problem areas that (like engineering) "contain a potentially unlimited number of possibly relevant facts and features" and identified five distinct stages in their 1986 book, *Mind over Machine: The Power of Human Intuition and Expertise in the Era of the Computer*, and subsequent writings:

1) The *novice* complies with strict rules based on context-free features of the task environment.
2) The *advanced beginner* recognizes situational aspects of the task environment and follows maxims to adjust his or her actions accordingly.
3) The *competent* performer does not try to account for all discrete elements of the task environment, but instead selects a plan, goal, or perspective for establishing which of them are relevant and which may be safely ignored.
4) The *proficient* performer no longer reflects on the task environment as a detached observer, but sees what needs to be done without having to evaluate multiple options, and then chooses how to go about doing it.
5) The *expert* intuitively perceives both what needs to be done and how to do it, making especially subtle and refined discriminations in a variety of task environments that are sufficiently similar to those previously encountered.

The higher levels can only be attained through extensive experience and are characterized by less rational deliberation and greater emotional involvement. As Dreyfus and Dreyfus put it, "When things are proceeding normally, experts don't solve problems and don't make decisions; they do what normally works."

A standard example is driving a car. The novice shifts gears based strictly on speed as conveyed by the instrument panel, while the advanced beginner also pays attention to less obvious cues like engine sounds. The competent driver, aware of multiple factors, may *determine* that he is going too fast, and then must decide what to do about it; while the proficient driver *senses* that he is going too fast. Finally, "The expert driver becomes one with his car, and he experiences himself simply as driving, rather than as driving a car."

The Dreyfus model is consistent with Billy Koen's thesis that the universal method for all aspects of human existence is the use of heuristics ("The Engineering Method," March 2006; "Heuristics and Judgment," May 2006). Initially we learn explicit rules and maxims, and over time we develop conscious and unconscious ways of decomposing and solving problems based on what has and has not worked for us. These are not necessarily procedures that we can communicate in words; they have become integral to who we are and how we operate, as long as we remain within the domains in which we are genuinely competent.

This is an important constraint to acknowledge. Even experts inevitably revert to the behavior characteristic of novices and advanced beginners when confronted with unfamiliar circumstances. They must fall back on rules and maxims, because they lack the kind or amount of experience that would enable them to discern the appropriate course of action on their own.

How does the Dreyfus model apply to engineering? Formal education primarily imparts rules for the novice, like calculating the maximum moment on a simply supported, uniformly loaded beam as $wL^2/8$. An engineer intern becomes an advanced beginner during the first few years of a career by picking up on maxims such as "least weight does not equal least cost" and their implications. Competence is achieved when an engineer is capable of employing independent judgment to focus on what really matters and converge relatively quickly on a viable solution.

Although it may be an accident of terminology, this appears to be where the bar is currently set for licensure. In particular, it is important to recognize that the law does not require engineers to be experts. Instead, courts have established a reasonable "standard of care" by which professional conduct is judged against how a typical practitioner would ordinarily perform in similar situations. In fact, those who call themselves "experts" may find themselves held to a higher standard – one that is not covered by their liability insurance.

That said, is competence – as defined by Dreyfus and Dreyfus – really sufficient to protect the safety, health, and welfare of the public? Given the complexity and life safety ramifications of structural engineering, perhaps the minimum qualification for those who are authorized to practice it should not be mere competence, but proficiency.

The new NCEES Structural examination appears to reflect this sentiment. It is 16 hours long, and half of the problems are in essay format, while all of the other NCEES PE exams are only eight hours long and consist entirely of multiple-choice questions. If passing those tests legitimately establishes that someone is competent, then it seems fair to say that passing the more rigorous Structural exam establishes that someone is proficient.▪

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