



Representation is intrinsic to human life and engineering practice. We communicate with other people throughout the design and construction process by means of words, diagrams, and sketches. We create mental and computational models of materials, loads, and the arrangement of members. We develop building information models (BIM), drawings, and specifications to indicate how the various pieces and parts are to be assembled into the finished structure.

The intent of these representations is to capture the relevant characteristics of reality, which may overlap but are not identical in each case. The engineer has to ascertain what those are, and then incorporate appropriate assumptions and simplifications accordingly. Two common strategies are abstraction, which involves neglecting certain aspects of reality in order to gain a better understanding of the remaining aspects; and idealization, which involves replacing a complicated and/or complex aspect of reality with a simplified version.

This entails that representations are always less than 100% accurate, raising the question of how they relate to reality – the domain of *semiotics*, the study of signs and signification (or *semiosis*). Conventional theories are *dyadic*, emphasizing two *components*: the signifier and the signified; the relationship between them is essentially arbitrary. The limitations of this conceptualization have become evident with the emergence of deconstruction and other aspects of postmodernism, in that it effectively precludes objective meaning.

An alternative was developed by American scientist and philosopher Charles Sanders Peirce (pronounced “purse”) in the late 19<sup>th</sup> and early 20<sup>th</sup> centuries. He founded what eventually came to be known as *pragmatism*, but was unhappy with the direction that it ultimately took in the more popular work of others – most notably William James and John Dewey – so he coined the name *pragmaticism* for his own approach, saying that this term was “ugly enough to be safe from kidnappers.” Peirce’s theory – which he preferred to call *semeiotic* – is *triadic*, emphasizing three *relations*: among the sign itself (or *representamen*), that which it signifies (*object*), and the effect that is produced (*interpretant*), which comes about by a habit of interpretation.

Peirce aligned these elements with the three fundamental categories that he identified in both our encounter with the world (phenomenology or *phaneroscopy*) and the underlying nature of reality (metaphysics); he simply called them *Firstness*, *Secondness*, and *Thirdness*. Firstness is quality, feeling, possibility, spontaneity, vagueness; Secondness is difference, reaction, actuality, persistence, particularity; Thirdness is mediation, purpose, regularity, order, generality. For example, an icon relates to its object through some kind of resemblance (Firstness), an index due to a physical or other direct connection (Secondness), and a *symbol* by means of a convention or rule (Thirdness). A painting is an icon, a fingerprint is an index, and a word is a symbol.

For Peirce, then, representation *is* reality: “...all this universe is perfused with signs, if it is not composed exclusively of signs.” Furthermore, all thought consists of signs, and *inquiry* is the deliberate and collaborative endeavor to process them in a way that results in genuine knowledge via three basic modes of inference: *abduction* (or *retroduction*), the formulation of a hypothesis or “guess,” often in response to a surprising event; *deduction*, the explication of what

else would be the case if that explanation is correct; and *induction* (or *adduction*), the examination of whether those consequences ever fail to materialize.

This “logic of inquiry” applies most directly to science, but it also serves as a “logic of ingenuity” in engineering practice. Abduction constitutes the creative process that leads to the selection of one preliminary solution out of multiple potential options (“Engineering as Willing,” March 2010). Deduction corresponds to the deterministic analyses that indicate the expected behavior of that design, given certain presuppositions. Induction operates over time as an engineer learns from experience – i.e., gets better at abduction – developing competence, proficiency, and eventually expertise (“The Nature of Competence,” March 2012).

Both inquiry and ingenuity thus employ signs to make that which is indeterminate *more* determinate, although never *fully* determinate. The only complete sign is the entirety of reality itself, which consists of continuous systems of relations, rather than discrete substances; hence its persistent complexity (“Complicated + Complex = Wicked,” July 2015). Truth is the *final interpretant* – the opinion on which an infinite community would converge after an indefinite investigation. In the meantime, we must always acknowledge the fallibility of our current understanding (“The Virtues of Ignorance,” May 2015). Uncertainty in representation is *constrained* by reality, but not eliminated entirely.

Note that determination occurs primarily as *discovery* in science (conforming representation to reality) vs. *decision* in engineering (conforming reality to representation). This distinction was important to Peirce, because while he was a persistent advocate of grounding science firmly in reason, he was equally adamant that practical matters should be governed primarily by instinct and sentiment. When it comes to “topics of vital importance,” judgment must rely on one’s existing beliefs, which are nothing more or less than established habits of thought and action – much like virtues in Aristotelian ethics (“Virtuous Engineering,” September 2013).

This column barely scratches the surface of Peirce’s wide-ranging and often idiosyncratic ideas. He never managed to write a single book – something that (so far) I have in common with him – but produced many thousands of pages of articles and manuscripts, leaving the bulk of them in draft or otherwise unfinished form. The Peirce Edition Project ([www.iupui.edu/~peirce/](http://www.iupui.edu/~peirce/)) has compiled and published key selections from his philosophical writings in *The Essential Peirce* (two volumes, 1992 and 1998). Helpful introductory and summary material is available in *The Fate of Meaning* (1989) and *Charles Peirce’s Guess at the Riddle* (1994) by John K. Sheriff, *The Continuity of Peirce’s Thought* (1998) by Kelly A. Parker, and *Peirce’s Theory of Signs* (2007) by T. L. Short. ■



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