The Logic of Ingenuity

Part 4: Beyond Engineering

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

This series began with the premise that the "logic of inquiry" in science, as expounded by Charles Sanders Peirce, also serves as a "logic of ingenuity" in engineering. I would like to revisit this notion by examining the *aim* of inquiry as asserted by Peirce in the title of one of his most famous essays, "The Fixation of Belief" (**www.peirce.org/writings/p107.html**). It appeared originally in the November 1877 issue of *Popular Science Monthly* as the first of six articles under the heading, "Illustrations of the Logic of Science," and subsequently as CP 5.358-387 and EP 1.109-123. According to the text:

> *Doubt is an uneasy and dissatisfied state from which we struggle to free ourselves and pass into the state of belief; while the latter is a calm and satisfactory state which we do not wish to avoid … The irritation of doubt causes a struggle to attain a state of belief (CP 5.372-374, EP 1.114).*

The first part of this quote indicates how the second part can be generalized: The irritation of *dissatisfaction* causes a struggle to attain a state of *satisfaction*. This happens to be exactly what Henry Petroski described as the governing principle of all invention and innovation in his 1992 book, *The Evolution of Useful Things*: "… the form of made things is always subject to change in response to their real or perceived shortcomings, their failures to function properly" (p. 22). He clearly had physical artifacts in mind, but the basic idea pertains to anything produced by humans – including scientific theories.

In other words, contrary to the common (but misleading) definition of engineering as "applied science," science is – at least in some ways – analogous to a discipline of engineering. Some might dispute this by claiming that science, unlike engineering, is primarily in the business of finding *truth*. Peirce agreed when discussing "science" as a collaborative endeavor by a large community of investigators working together over an extended period of time. However, for a single individual under ordinary conditions:

> *… the sole object of inquiry is the settlement of opinion. We may fancy that this is not enough for us, and that we seek, not merely an opinion, but a true opinion. But put this fancy to the test, and it proves groundless; for as soon as a firm belief is reached we are entirely satisfied, whether the belief be true or false (CP 5.375, EP 1.114-115).*

Therefore, truth is the goal of inquiry only in the long run, and only in the sense that our ongoing interaction with nature – what Peirce called the "Outward Clash" (CP 8.41-43, EP 1.233-234) – prevents us from ever being *permanently* satisfied with our beliefs by periodically confronting us with evidence that some of them are false. By contrast, the goal of ingenuity is something that we hope to achieve in the short term: *solving a problem*, typically despite incomplete knowledge and limited resources. Adapting Peirce's phrasing once again: The irritation of *uncertainty* causes a struggle to attain a state of *decision*; or as he wrote in the subsequent article, "How to Make Our Ideas Clear" (**www.peirce.org/writings/p119.html**), "The *final* upshot of thinking is the exercise of volition" (CP 5.397, EP 1.129; 1878).

This implies that the *logic* of ingenuity may be applicable to the contemplation of *any* potential activity that could be undertaken voluntarily. It thus extends beyond engineering, into the much broader domain of *ethics*. And yet, by his own admission, Peirce did not have much to say about that subject until relatively late in his career. In a 1903 lecture, he classified it with esthetics and logic as "The Three Normative Sciences" (CP 5.120-150, EP 2.196-207):

> *For normative science in general being the science of the laws of conformity of things to ends, esthetics considers those things whose ends are to embody qualities of feeling, ethics those things whose ends lie in action, and logic those things whose end is to represent something … That is right action which is in conformity to ends which we are prepared deliberately to adopt (CP 5.129-130, EP 2.200).*

Peirce came to see that logic is a form of ethics because thought is a form of conduct; and that self-control is essential to both thinking well and acting well because we cannot influence the past or the present – only the future. In another lecture later the same year, he posed the question, "What Makes a Reasoning Sound?" (EP 2.242-257) and answered it by explicitly drawing a parallel with what makes an action morally right. Daniel G. Campos, a philosophy professor at Brooklyn College of the City University of New York, summarized six stages identified by Peirce in a 2015 paper, "The Role of Diagrammatic Reasoning in Ethical Deliberation" (*Transactions of the Charles S. Peirce Society*, Vol. 51, No. 3, pp. 338-357):

1) Affirming *ideals* that together constitute a worldview and shape one's character.
2) Establishing an *intention* to behave in accordance with those ideals.
3) Formulating *rules of conduct*, "practical maxims for what ought to be done in circumstances that fall under a more or less vague description."
4) Making a *resolution* for how to act if and when a specific occasion arises that is foreseen through the use of "semiotic imagination – the ability to create and transform signs – guided by practical knowledge of what paths events may follow."
5) Converting this resolution into a *determination*, an abiding disposition that is "capable of effectively guiding conduct."
6) Engaging in a critical *review* of one's actions in relation to all of the above, which produces approval or disapproval of the former – and sometimes revision of the latter.

Peirce wrote of the fourth step, "This resolution is of the nature of a plan, or, as one might almost say, a *diagram*" (EP 2.246). Prompted by this hint, Campos suggested that each of the others is likewise analogous to an aspect of diagrammatic reasoning – although, in both cases, "we must keep in mind that this is a continuous process and that its various stages may be more or less emphatically experienced in different contexts." In the same order as above:

The Logic of Ingenuity

The process of (abductively) creating a diagrammatic representation of a problem and its proposed solution, and then (deductively) working out the necessary consequences, such that this serves as an adequate substitute for (inductively) evaluating the actual situation.

1) Ideals correspond to a set of "framing hypotheses" that comprise a representational system.
2) An intention corresponds to the purpose of the exercise.
3) Rules of conduct correspond to "heuristic[s] … that direct an inquirer to employ a certain method of solution depending on the general type of problem under investigation."
4) A resolution corresponds to "a mathematical model that may be formulated and investigated abstractly but is intended to apply to a concrete state of things."
5) A determination corresponds to the intellectual virtue of judgment that eventually emerges from "mathematical experience."
6) Review corresponds to the observation of the results of diagram manipulation.

This analysis aligns with my persistent claim that engineering is an especially systematic way of willing – if I am right, then the former's distinctive reasoning process *should* be paradigmatic for the latter. However, contrary to the profession's traditional reputation, this does not entail the use of a *quantitative* model in every instance. For example, rather than an abstract formalization, it might be – and in ethical scenarios, often is – constructed as a *narrative* instead. After all, engineering mostly deals with material phenomena, which Peirce conceptualized as "inveterate habits becoming physical laws" (CP 6.25, EP 1.293; 1891). The behavior of people, on the other hand, is always subject to change – our habits are far more malleable, which makes us far less predictable.

Regardless, the key to success is having the ability to discern the significant aspects of reality and consistently capture them, *before* definitively selecting a way forward from among multiple viable options. The logic of ingenuity is thus *itself* a carefully cultivated habit that facilitates imagining possibilities, assessing alternatives, and choosing one of them to actualize – in engineering, in science, or in any other endeavor.▪

*Jon A. Schmidt (**jschmid@burnsmcd.com**) is a Senior Associate Structural Engineer in the Aviation & Federal Group at Burns & McDonnell in Kansas City, Missouri. He serves as Secretary on the NCSEA Board of Directors, chairs the SEI Engineering Philosophy Committee, and shares occasional thoughts at **twitter.com/JonAlanSchmidt**.*

References

In accordance with standard scholarly conventions, Peirce's works are cited as follows, along with the year when he authored the quoted text where this is not already given. CP with volume and paragraph number(s) is *The Collected Papers of Charles Sanders Peirce*, edited by Charles Hartshorne, Paul Weiss, and Arthur W. Burks, published by Harvard University Press in 1931-1935 and 1958. EP with volume and page number(s) is *The Essential Peirce*, edited by Nathan Houser, Christian Kloesel, and The Peirce Edition Project, published by Indiana University Press in 1992 and 1998.