

Yakov Ben-Haim and Scott Cogan, 2023, Paradox of optimal learning: An info-gap perspective, *ASCE-ASME Journal of Risk and Uncertainty in Engineering Systems, Part B: Mechanical Engineering*, to appear.

Abstract Engineering design and technological risk assessment both entail learning or discovering new knowledge. Optimal learning is a procedure whereby new knowledge is obtained while minimizing some specific measure of effort (e.g. time or money expended). A paradox is a statement that appears self-contradictory, or contrary to common sense, or simply wrong, and yet might be true. The paradox of optimal learning is the assertion that a learning procedure cannot be optimized *a priori* — when designing the procedure — if the procedure depends on knowledge that the learning itself is intended to obtain. This is called a reflexive learning procedure. Many learning procedures can be optimized *a priori*. However, *a priori* optimization of a reflexive learning procedure is (usually) not possible. Most (but not all) reflexive learning procedures cannot be optimized without repeatedly implementing the procedure which may be very expensive. We discuss the prevalence of reflexive learning and present examples of the paradox. We also characterize those situations in which a reflexive learning procedure can be optimized. We discuss a response to the paradox (when it holds) based on the concept of robustness to uncertainty as developed in info-gap decision theory. We explain that maximizing the robustness is complementary to — but distinct from — minimizing a measure of effort of the learning procedure.

Keywords optimal learning, uncertainty, robustness, learning paradox, info-gaps.