14D **ADDITIONAL ON DESIGN**

Design

To design is to devise or create according to a plan. Design refers to something that has been intentionally created by a thinking agent (as opposed to random generation).

Engineering Design

Engineering design is a systematic, creative, iterative process for addressing a problem or a technical opportunity. Engineering design involves specific steps, beginning with problem identification and concluding with a finished product, result, or system.

Engineering design is viewed as a creative endeavor that proceeds in an environment of uncertainty, from known condition to unknown. Design solutions are framed by constraints, such as cost and safety. Though engineers are constrained by nature, and must rely upon mathematics and scientific principles, they differ from scientists in the extent to which they draw upon heuristics rather than scientific laws in making design decisions. [1]

Design may be

- Innovative/original
- Adaptive
- Re-design

Aspects of real-world design include:

- Creativity and innovation
- Modeling, including use of software packages
- Predicting results under extreme conditions
- Specific parts selection
- Manufacturing considerations

Multiple categories of design exist:

- Product design
- Process design
- Industrial design (Robust products for mass production)
- Enterprise design
- Hardware design
- Software design
- Interface design
- System design
- Computer-Aided Design
- Frontier design
- Human-centered design

- User-centered design
- Universal design (accessible, barrier-free, inclusive)
- User-experience design (including branding, usability, function)
- Active design-guidelines for healthy buildings and spaces
- Green design –minimum impact on the environment
- Biologically-inspired design
- Participatory design
- Disruptive design
- Agile design
- Circular design
- Speculative design
- Life-centered design
- Design for X (manufacturing; assembly; testing; quality; cost; maintenance; reliability; packaging; sustainability; disassembly; supply chain; safety; rapid time-to-market; logistics; security; ergonomics)
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Design Values

Lambert Van Poolen, following McGinn, suggests the following: [2]

1. *Primary products of design are to fulfill value-laden purposes and reflect values of maker and user.*
2. *Design always involves tradeoffs between using resources for the short term or long term.*
3. *Imbedded in each artifact are expressions, objectifications or crystallizations, of the individual preferences, idiosyncrasies, world views, and cultural values of the designers or makers or those for whom they labor…*
4. *All of design is value-laden.*
5.

Risk and Design

Risk was added to ABET's design definition in 2019.

Engineering Design: Consideration of risk has been added to the definition. It is expected that the listed characteristics and phases of the design process will be incorporated somewhere in the curriculum. ***It is not necessary that all phases be contained in the major design experience***. [3]

Risk could refer to technical risk, safety risk, or technological risk.

Some aspects of risk and safety-

The first step in the risk management process is the identification of risks. Risks can be identified using a number of processes…Some of the more common approaches include:

- System safety assessments – fault tree analysis, hazard analysis, failure modes and effects analysis
- Brainstorming
- Quantitative risk assessments
- Test and verification
- System and software engineering
- Pause and learn sessions
- Program planning and control – cost and schedule risk analysis
- Experience – previous analysis, lessons learned, historical data
- Models and simulations [4]

Guidelines for risk management [5]

1. Identify/anticipate risks and hazards
2. Analyze risks – likelihood, consequences
3. Develop mitigation and contingency strategies
4. Communicate , control, and track risks (inspections, testing, training, auditing)
5.

Design and Purpose

Richard Dawkins and others have repeatedly argued that the human eye and the panda's thumb are inefficiently designed and therefore are actually evidence that there is no wise Creator of all life. Is this a valid position?

Brad Sargent writes-

As a designer of medical devices, I believe that critics like [Richard] Dawkins use the wrong criteria to decide what is and is not a good design. Every engineer tends to criticize how another engineer solved a problem. By nature, we like to believe we could have done a better job. But many times it turns out we just didn't understand the problem well enough to judge. It is interesting to see how many supposed examples of bad design in nature turn out to be better than we initially understood. The complexity of a problem takes time to understand because of the subtle interaction between the parts of a system.

The panda's thumb and the human eye are prime examples of misunderstood designs. The more we study them, the more they exhibit good design. For example, the panda's thumb doesn't have the versatility and capability of the human thumb, but it works well for the repetitive motion of stripping bamboo leaves. The human thumb couldn't take that kind of constant stress…

{We need to] avoid being hasty in declaring a design "bad" simply because it wasn't engineered the way we think it should have been. (The fault for other supposed design flaws—like my need for glasses—rests more on corrupted manufacturing instructions than an actual flaw.)

We must also keep in mind that all designs require tradeoffs. At the company where I work, when a client brings us an idea for a new or improved product, the first step is defining the specifications for the new device. For medical devices, this is an essential part of the FDA

Design Control process. The exercise usually starts like writing a wish list for Santa. Our experienced clients know they can't have it all, but figure why not aim high? Everyone wants the new device to be better than the competition. The product must be smaller yet have longer battery life and a bigger display, be lighter yet more rugged and durable, be simpler and easier to use yet include more features. And, of course, it should be cheaper, too…

In regards to God's designs in nature, we need to look at the big picture. We no longer need to debate whether the panda's thumb is optimally designed. We need to ask, "What was God's purpose for the panda?" If the panda is fulfilling that purpose, then there should be no complaint about its thumb. Imagine a creature optimized according to our standards. That animal would most likely overrun its environment and unbalance the ecosystem. [6]

Physicist David Snoke has looked in detail at the case for Intelligent Design (ID): [7]

This argument is intrinsically an inductive argument, as follows:

1. In our experience, some things are known to be designed by intelligent agents, namely us, or animals with some degree of intelligence.

2. In our experience, some other things are known to not be designed by intelligent agents.

3. In our experience, we find that all of the things which we know to be designed by intelligent agents have certain properties, and none of the things which we know are not designed have those properties.

4. Therefore, when presented with something of unknown history, if it has the properties of a designed thing, then we conclude inductively that it is designed by an intelligent agent.

Three objections have been raised to ID:

Those who embrace ID concepts already (and sometimes in a hidden way) believe in the God of the Bible and use ID to their advantage.

However, notes Snoke, a number of prominent ID adherents would not identify as Christians, including Anthony Flew, Paul Davies, Michael Denton, Mustafa Aykol, and Gerald Schroeder. [8]

Additional considerations

1. Some apparently less-than-optimal areas exist in life, which point away from an intelligent Creator.

This argument has been addressed above.

2. ID may point to an intelligent designer, but not necessarily to the God of the Bible.

This is true. Design in nature is one significant data point, consistent with God's revelation in the Bible.

3. While some things (the human circulatory system, for example) are sufficiently complex as to suggest design, other things in nature (rocks by a river) may not look "designed."

Would anyone suggest that God didn't also design the rocks?

There are a number of possibilities for the things we find:

- Directly caused by miraculous action of God.
- Indirectly formed by the forces and physical laws of nature (which God designed).
- Formed by events "rigged" by God by means of specially chosen initial conditions).
- Formed by what we would describe as random processes (arrangements of gas molecules, semiconductor properties, piles of dust), but understood by God.
- Caused by actions unknown to us (but known to God).

At the lowest level, all things have design in the sense of obeying well-designed laws of nature. At a higher level, some things have even higher levels of design, in that they demonstrate patterns which cannot be derived solely from the lower levels of design…

Finding something further down in degree of design does not imply that nothing has design. For example, finding a simple little ditty written by Mozart does not mean he was a poor composer; finding a Mercedes-Benz with hubcaps which are not as aerodynamic as we might like does not mean the car was made randomly. People make various things for various uses, and there is no reason why God could not do the same…

In my domain of observation, there are some things, like rocks, which are well designed in one sense, in that they obey well-designed laws of nature, but there are other things, such as living systems, which have an additional level of design that cannot be derived from the lower-level design alone. It is therefore improper to say that the ID view sees God only in the miraculous and not in the commonplace. [9]

References

1. Lewis, T., "Coming to Terms with Engineering Design as Content," *Journal of Technology Education* Vol. 16 No. 2, Spring 2005.
2. Van Poolen, L., "Technological Design: A Philosophical Perspective," *ASEE Annual Conference Proceedings*, 1987, p. 768 ff.
3. "FAQs for EAC C3 & C5 Criteria Changes," ABET, 2019.
4. "Guidelines for Risk Management," NASA.
5. Ibid.
6. Sargent, B., "Design with a Purpose," http://www.reasons.org/articles/design-with-a-purpose
7. Snoke, D., "Defining Undesign in a Designed Universe," *Persp. Sci. Chr. Faith* 60 (4), Dec. 2008, p. 225.
8. Ibid.
9. Ibid.