Favorable Properties of a Design Method

1. The method should provide a rank ordering of candidate designs.
2. The method should not impose preferences on the designer.
3. The method should permit the comparison of design alternatives under conditions of uncertainty and with risky outcomes.
4. The method should be independent of the discipline of engineering.
5. If the method recommends alternative A when compared to the set of alternatives S={B,C,D,...}, then it should also recommend A when compared to any reduced set such as S_R={C,D,...}.
6. The method should make the same recommendation regardless of the order in which the design alternatives are considered.
7. The method should not impose constraints on the design or the design process.
8. The method should be such that the addition of a new design alternative should not make existing alternatives appear less favorable.
9. The method should be such that information is always beneficial.
10. The method should not contradict itself.
11. It should be possible to validate the method.

The Bottom Line

- All design tools do one or more of three things:
  - Aid in the creation/definition of design alternatives (develop the alternative set),
  - Aid in the evaluation of design alternatives (evaluate expectations),
  - Aid in the selection of a preferred design alternative (determine preferences and apply them to obtain a choice).
- Selection is decision making. It is the same as optimization.
- Optimization theory deals with search techniques, given an objective function and constraints.
- Decision theory deals with proper formulation of the objective function.
- Both are needed to do design.
- Both have been treated extensively in the literature.
- Expectations always involve uncertainty resulting in risk.
- The methods used must be valid under conditions of uncertainty and risk.

Common Mistakes

- Failure to recognize that decisions are being made in design
- Neglect of uncertainty and risk
- Trying to assign preferences to things upon which the decision maker has no preference
- Failure to recognize the role that preferences play in decision making; attempts to devise methods to "solve the design problem"
- Failure to assign uncertainties only to expectations
- Failure to use an appropriate utility (objective) function and failure to validate the function used
- Using the preferences of someone other than the decision maker in a particular decision analysis (Lewis Carroll, Alice in Wonderland)
- Failure to acknowledge Arrow's Theorem--groups generally do not have rational preferences (customer preferences cannot be used to guide design, must rely on demand to account for customers)
- Failing to understand the role of management in engineering design

So, What's Important

1. Design research should be scholarly, it should acknowledge and reference relevant research results, even if they are 300 years old.
2. Design research should not go against relevant accepted extant theory in an ad hoc manner.
3. Design research should build on previous relevant research.
4. Design research should lead to mathematically sound methods, that is, it should not lead to methods that are based on mathematical mistakes or misconceptions.
5. Design research results should be validated (case studies do not validate such methods).